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ABSTRACT

The document presents a summary of the proceedings of the Engineering Foundation Conference organized by the Engineering Manpower Commission. The conference was conducted to identify engineering manpower problems and needs and the effects of the national economy and government policies on engineering manpower. The document is divided into three parts. Part 1 presents an overview of the conference by Chairman Paul Doigan and a list of recommendations for the government, employers, and educators. Part 2 presents summaries of presentations given by 31 speakers, a summary statement by Cornelius Wandmacher, and biographical information on the 37 participants. Part 3 contains the texts for the following key presentations: (1) Where We Are Today--A View from the Engineering Profession, John D. Alden; (2) Concerns of Engineers, Roger D. Zimmerman; (3) National Science and Technology Policy, Russell C. Drew; (4) Remarks at the Engineering Foundation Conference, Daniel Hecker; (5) Engineering Manpower and a National Education Policy, Israel Katz; (6) Remarks to the Engineers Joint Council Manpower Conference Committee, Warren C. Stoker; and (7) Engineering Manpower and a National Education Policy--Continuing Education of Engineers, R. R. O'Neill. The conference agenda and a list of the participants is included. (EC)

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PROCEEDINGS OF
THE ENGINEERING FOUNDATION CONFERENCE
HENNIKER, NEW HAMPSHIRE JULY 13-18, 1975

Sponsored by
The Engineering Foundation
345 East 47th Street
New York, New York 10017

ENGINEERING MANPOWER

A NATIONAL PROBLEM OR A NATIONAL RESOURCE?

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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ENGINEERS JOINT COUNCIL

ENGINEERS JOINT COUNCIL (founded in 1941 and incorporated in 1958) is an organization of engineering societies whose general objective is to advance the art and science of engineering in the public interest.

In furtherance of this general objective the Council shall:

(a) Provide for regular and orderly communications among its member societies.

(b) Act as an advisory and coordinating agency for member society activities, as mutually agreed.

(c) Organize and conduct forums for the consideration of problems of expressed concern to member societies.

(d) Identify needs and opportunities for service in the engineering community and inform the concerned engineering institutions.

(e) Recommend appropriate programs of studies and research to engineering institutions and especially to member societies.

(f) Undertake, in accordance with policies mutually agreed to, specific activities or projects that the member societies acting individually could not accomplish as well.

(g) Represent the member societies when they deem such joint representation desirable.

THE ENGINEERING MANPOWER COMMISSION OF ENGINEERS JOINT COUNCIL

The Engineering Manpower Commission was organized in 1950 as part of Engineers Joint Council, to serve as a focus for national technological manpower problems.

The Commission's program is carried out through the collection, analysis, and publication of significant data on engineering manpower, as well as the development of programs and policies designed to acquaint the public with the importance of engineering to the national welfare.

The Engineering Manpower Commission is charged with the following responsibility:

"To engage in studies and analyses of the supply, demand, and utilization of engineering and technical manpower; to make recommendations, conduct programs, and develop reports concerning these aspects of engineering and technical manpower; and to carry on such other programs in the field of manpower as may be authorized by the Board of Directors of EJC."

EMC OFFICERS AND STAFF

Arthur F. Hartford ..... Chairman

Edward T. Kirkpatrick ..... Vice-Chairman

Arthur W. Gilmore ..... Vice-Chairman

John D. Alden ..... Executive Secretary

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FOREWORD

The Engineering Foundation Conference on "Engineering Manpower, A National Problem or a National Resource?" was held at Henniker, New Hampshire during the week of July 13, 1975. The purpose of the Engineering Foundation Conferences is "to define gaps in engineering related knowledge. . .and then to find ways to fill these gaps. This is achieved by an informal type of meeting consisting of speakers and discussion groups meeting in congenial surroundings remote from the press of daily business." Meeting sessions are held in the mornings and evenings leaving afternoons free for ad hoc meetings or recreation. As a general rule, proceedings are not usually published and no information presented at the conferences is to be used without the authorization of the person making the presentation. However, it was the first conclusion of the conferees that the proceedings of the manpower conference should be published. The summaries of each speaker's remarks have been reviewed and approved in accordance with this procedure.

It was the specific purpose of the organizers and sponsors of this conference to reach the following objectives:

(1) Identify engineering manpower problems that lend themselves to a national approach.

(2) Identify the effects on the national economy of engineering manpower supply/demand imbalances.

(3) Identify government policy effects on engineering manpower.

(4) Achieve greater understanding and exchange of information among conference participants.

(5) Identify the need for a national education policy.

(6) Develop recommendations to pass on to appropriate sectors in government, private industry, education, and professional societies.

Since it is seldom feasible for a conference of this type to reach a formal set of conclusions and recommendations, the recommendations set forth in this report represent a distillation and consolidation of those that were expressed both formally and informally in the conference presentations, workshops, group discussions, and ad hoc conversations. They were put together, reviewed, and recast into a consistent whole by members of the conference planning committee. They were then mailed to all the attendees for review and comment. The final result, as published herein, represents the consensus of the conferees as to what needs to be done to resolve the nation's engineering manpower problems. The recommendations will be subjected to further review by the Engineering Manpower Commission and Engineers Joint Council, after which some or all of them will be addressed to the various organizations that must take action to implement the recommendations. Until then, the recommendations are to be regarded as those of the conference, not of the Engineering Manpower Commission, Engineers Joint Council, the Engineering Foundation, or any of the co-sponsoring organizations.

The Engineering Manpower Commission is appreciative of the assistance provided by Dr. Sandford S. Cole and Ms. Melissa Keesberg of the Engineering Foundation in making this conference possible, and of the work done by the speakers and other participants in making it a success. The support of the Engineering Foundation in helping to defray the cost of printing these proceedings is also gratefully acknowledged.

John D. Alden
Executive Secretary
Engineering Manpower Commission

PART I

AN OVERVIEW OF THE CONFERENCE

by Paul Doigan, Chairman

"Engineering Manpower—A National Problem or a National Resource" was the topic of this Engineering Foundation Conference organized by the Engineering Manpower Commission and co-sponsored by twenty-one technical societies, and held at New England College, Henniker, New Hampshire on July 13-18, 1975. Of the 85 attendees, 37 took leadership roles as speakers, panelists, or discussion moderators, thus achieving a very high degree of active participation on the part of the conferees. All sectors of the community were well represented, with sizable groups of attendees from industry, education, the federal government, and professional societies.

The program for the first day, "Engineering Manpower—Where We Stand Today," was keynoted by Dr. Myron Tribus, Center for Advanced Engineering Study, Massachusetts Insitute of Technology, who challenged the conferees to decide where they wanted the engineering profession to stand as it moves ahead. He identified five major problems affecting engineers today:

- a vacuum in national technological planning;
- national policies leading to a decline in the productivity of technology;
- absence of engineers from national decision making;
- failure of academia to prepare students for the realities of engineering work; and
- a breakdown in the self-image of engineers.

He made it clear that taking a stand on most of these issues would ultimately require that engineers involve themselves in political action, something that other professional groups had long understood. Engineers have seemingly been taught to shun power and let themselves be exploited by others.

A panel moderated by Arthur Hartford, E.I. duPont Company, attempted to bring everyone up-to-date on the status of engineering manpower. John Alden, Engineering Manpower Commission, described the current engineering college enrollment and degree data and the demand survey which has been conducted by EMC over the past two years.

Dr. Charles Falk described the engineering profession in relation to other elements of the U.S. labor force as portrayed by National Science Foundation data. Although engineers make up 65% of the combined science/engineering group, they constitute only 1.2% of the total labor force. It was clear from this presentation that engineers do not command much attention on the part of most government agencies concerned with manpower problems, simply because their numbers are relatively small in comparison with the total work force.

Mr. Norman Harvey, the Manpower Administration of the U.S. Department of Labor, pointed up a situation in which his agency was aware of 6,900 unfilled engineering openings recently listed in the federal/state employment service job banks at the same time that large numbers of engineers were known to be unemployed, and was unable to bring together jobs and job seekers. It would appear that the engineering profession itself should be able to do a much better job of placing engineers than the government employment agencies.

On the industry side, Mr. Paul McGrath, General Motors Corporation, described his company's program of Human Resources Management, involving a review of the past and present compositions of the technical work force and a conscious effort to achieve an optimum manpower mix for the future. One noteworthy finding, a large number of engineering graduates in positions where an engineering degree is not really needed, has resulted in a higher proportion of business graduates being employed.

Mr. Harold E. Roush, RCA, moderated the panel on "Concerns of Engineers." Representing the Association of Scientists and Professional Engineering Personnel, an engineering union, Mr. Harold Ammond reported on a significant shift in the attitude of engineers as noted by their vote to join the Teamsters Union at McDonnell-Douglas and to affiliate with the United Auto Workers at Convair. These new affiliations with national unions are expected to stimulate major organizing efforts by the AFL/CIO, Teamsters, and United Auto Workers to compete for a share of the nation's engineers who are considered ripe for unionization due to concerns over job security, salary, and working conditions.

Expressing the concerns of women engineers, Naomi McAfee noted that they are succeeding in breaking down old prejudices and are beginning to worry about charges of reverse discrimination. Women in engineering are seeking real career development opportunities and wish to avoid the dangers of "tokenism" and showcase jobs without real engineering contact.

Expressing the concerns felt by educators, Roger Zimmerman, New Mexico State University, discussed the future role of technicians and technologists in the overall engineering manpower picture, the image of engineering among young people and the general public, the imbalances among the engineering disciplines, and the overall organization of the profession. He stressed the importance of lifelong career development and suggested that ECPD consider accrediting industry's programs toward that end.

Basic national trends affecting industry's utilization of engineers, including continued growth of government, more economic regulation of industry, and expanding government subsidization of education were noted by Mr. Bryce MacDonald, Kennecott Copper Corporation. He envisioned that in the future it might be more difficult for people to enter the engineering profession or to shift activities within it; conditions of employment will continue to be more formally defined, and organized bargaining is likely to increase; and the profession will devote increased attention to organized political impact.

Workshop sessions reviewing the discussions of the day, with the principal speakers serving as discussion leaders, were held on Monday evening.

The theme for the second day of the Conference was "Engineering and the National Economy." Relating economic growth and productivity, Mr. Warren Alberts, United Airlines, opened the session by noting the high economic growth and productivity made by U.S. agriculture over a 25-year period, attained. interestingly enough, through the utilization of existing technology on existing products—one of the four areas mentioned in the keynote address on approaches to growth. In reviewing economic growth and productivity of the U.S. versus several of the larger foreign countries, he showed that the U.S. was lagging in both areas, making it more difficult to compete with these nations on an equal footing.

Dr. Edward Kirkpatrick, Wentworth College of Technology, moderated a panel discussion relating manpower and the national economy. An analysis of engineering unemployment, presented by Dr. Ronald Kutscher, Division of Economic Growth, U.S. Department of Labor, showed that engineering unemployment is usually not sensitive to economic cycles but rather to government programs; however, in this recession engineering unemployment has followed the economic cycle. Because of the lack of purchasing power and key industries to lead the nation out of this recession, recovery this time will be slow. In other depressed periods, the country had the auto industry and the building and construction industries to lead the way. The implication is that engineering employment will also be slow in recovery, with BLS predictions that the total unemployment will still be about 7% in 1977. Dr. Vincent Wright, Stone and Webster, noted that the U.S. economy has tremendous potential if properly managed, and the best way for the nation's growth to take place is through the market place and not through controls and edicts. It is an almost impossible task to have a balanced economy under conditions such as we have with 65% of today's economy made up of service industry, of which the government is the largest factor, and only 35% income producing industry.

The nation's eroding economy is due greatly to foreign competition in technology, Dr. Nagaraja Rao, M.I.T.'s Center for Policy Alternatives, observed. Using the automotive industry as an example, he noted that most of the recent developments in improved automobile engines have come from either Japan or Western Europe. To maintain a growing economy, it is essential to increase the rate of innovation, which he claims could be accomplished with minimum economic burden through proper tax incentives. He emphasized the need for technical manpower training to concentrate on future technical problems and not on current day technology.

The relationship between the national economy and engineering employment through the development of a mathematical model was presented by Dr. Fred Landis, University of Wisconsin at Milwaukee. Although his model made assumptions which were not valid in all cases, it nevertheless was indicative of trends. For example, during periods of recession it showed that it might be better to transfer technical personnel to R&D effort rather than to lay-off and transfer to public works projects, because the recession would be over by the time approvals and appropriations could be made available to utilize the people. It was concluded that mathematical models can be useful tools for projecting manpower and economic data into the future; however, caution should be exercised regarding the assumptions made.

Again on Tuesday evening small group discussion workshops led by the principal speakers of the day's program were held.

The program for the third day, devoted to Engineering Manpower and Government Policy, was chaired by Mr. David Reyes-Guerra, Engineers' Council for Professional Development. The keynote speaker for the day, Dr. Russell Drew, National Science Foundation, discussed four major areas: the attitude of the National Science Foundation and Washington toward engineering manpower, the structure of the proposed new office of Science and Technology Advisor to the President, some suggestions on how to get things done through the government hierarchy, and major federal trends in engineering manpower.

Mrs. Jean Moore, Board of Engineering Manpower and Education Policy, National Research Council, chaired a panel on Minorities and Women in Engineering. The role and responsibilities of the Committee on Minorities of the National Research Council was discussed by Mr. Melvin Thompson, its executive director. He described the four major subcommittee activities; pre-college guidance, engineering education, finance, and manpower utilization. He also noted that there are measurable trends showing growth in minority engineering enrollments. The target for the minority engineering effort is to reach parity in engineering enrollments for underrepresented minorities (Blacks, Spanish-surnamed, and American Indians) by 1982, and he expressed strong optimism for reaching or exceeding this target.

Miss Carolyn Phillips, President of the Society of Women Engineers, in discussing the society's activities noted that membership has greatly increased to over 3,000, of whom two-thirds are student members. She indicated that enrollments have increased several-fold during the last five to six years, but attrition is still a problem. She believes that once women are well accepted in engineering, the need for SWE will dissolve.

In discussing the Commission's role as an employer, George White, U.S. Civil Service Commission, indicated that they have had the same problems as industry in employment of minorities. Some regions are doing much better than others due to enlightened attitudes and, although upward mobility has improved in the past five years, the rate of progress is being carefully scrutinized. A startling statistic, which he revealed, showed that the Civil Service Commission hired over 12,000 minorities out of a total of 19,000 hired during Fiscal '73-'74.

The Minority Engineering Education Effort, ME³, was described by Mr. David Reyes-Guerra, Engineers' Council for Professional Development, as a plan to encourage minorities to take engineering training. This is accomplished primarily through printed material, pamphlets, and two movie films. All materials can be obtained from ECPD headquarters in New York.

In general, the panel concluded that engineering enrollment gains are being made for both women and minorities but problems still persist in attrition. The programs described by the panelists all aim toward helping with current and future problems.

Mr. Robert Ainsworth, National Commission for Manpower Policy, discussed the role and structure of the Commission which was established by Congress in 1974. Dr. Eli Ginzberg, Columbia University, is the Director and is supported by a board of 11 public and private citizens. The work of the Commission to develop a national manpower policy as described by the speaker, left the impression that the goals were diffuse, no timetable had been established, and in general, the board structure was not conducive to obtaining results of relevance to engineering.

The Role of National Data Programs in Establishing Policy was the topic for the distinguished speakers from three government agencies who addressed the conference on the evening of the third day. Their presentations revealed serious inconsistencies in the various approaches to engineering manpower data and led to some sharp questioning of the interpretation and significance of the data.

Mr. Norman Seltzer, National Science Foundation, created a great deal of interest with his report on the characteristics of engineers as found by the 1972 post-censal survey. Highlights of this study and comprehensive tabulations of data from the survey were reported. He pointed out that the redefined engineering population numbers just under one million of which only 5% are either unemployed or out of the labor force. Only 15% of the group employed are classified as managers or administrators, while over 80% consider themselves employed as engineers. Approximately 70% of engineers employed in industry hold BS degrees while about 20% and 10% hold MS and PhD degrees respectively. On the other hand, in universities their ratio is quite different with only about 20% holding BS degrees, 30% MS and almost 50% holding a doctorate. The entire study is reported in NSF 75-313 dated May 1975.

The Bureau of Labor Statistics was represented by Mr. Daniel Hecker who explained how his agency arrived at projections of engineering manpower needs for the next decade. BLS projects a growth in engineering employment from 1,100,000 in 1974 to 1,500,000 by 1985. Requirements for 36,000 new engineers per year would be needed to sustain such growth, while another 40,000 per year would be needed to replace losses through retirement, death, and transfers out of engineering. BLS estimates that this manpower will be supplied by inputs from new engineering graduates, graduates from other bachelor's degree programs, immigrants, and other sources, primarily upgraded technicians and transfers into the engineering work force.

Martin Frankel of the National Center for Education Statistics described his office's programs for collecting data on engineering students and graduates and for projecting the future supply of graduates on the basis of past trends. He suggested that it would be most helpful for him to meet with knowledgeable people from the engineering community in order to get a feel for changing educational trends before making future projections.

Chairman for the fourth day's sessions on Engineering Manpower and a National Education Policy was Dr. M. E. VanValkenburg, University of Illinois. Four speakers from the academic sector and one from industry discussed Continuing Education of Engineers. Dr. Russell O'Neill, University of California at Los Angeles, pointed out that continuing education was most important for the engineering profession because in many instances it is what determines how long and how effectively people will perform as practicing engineers. The need for more attention to the planning, operation, and evaluation of both formal and informal continuing education programs was stressed. Engineering manpower is one of the nation's most important resources; fortunately, it is renewable, but we have to use it properly and conserve it as well. He felt that universities, in general, had failed to design curricula which are really responsive to the needs of the profession and the practicing engineer.

It was reported by Dr. Peter Chiarulli, Illinois Insititute of Technology, that studies have shown that participation in continuing education is positively related to job satisfaction and salary. He stressed that continuing education must be done during the regular work week to be most effective and employers must build into their systems continuing education as a cost of doing business. With respect to degrees, he suggested that if each child at birth were given two certificates—a birth certificate and a PhD degree—then we could get on with the serious business of learning what we want to learn. However, he recognized that continuing education experiences must be given some recognition as accomplishments and, in that regard, suggested that we might take a lesson from other professions and think in terms of an "in-service record" where learning experiences could be recorded for proper recognition by one's peers and management.

A picture of what is needed for a successful professional development and continuing education program was presented by Mr. Israel Katz, Northeastern University. He described five areas as essential: *learning on the job* (90-95% of learning occurs here—a Harvard study revealed that 80% of our professionals learn 95% of what they need to know to keep doing what they are doing by doing it—learning on the job!!); *learning readiness* on the part of the individual (it is most difficult for someone out of a job to retrain—he has other worries); *informational content*; a *responsive agency* to organize the material, select

the instructor, etc.; and a *sponsor* or someone to pay the bill.

Dr. Warren Stoker, Rensselaer Hartford Graduate Center, speaking from the vantage point of a graduate institution dedicated to fulfilling the educational needs of business and industry in its area, described his institution's mission ". . .to meet the educational needs of working professionals—what is commonly referred to as professional education or continuing education." He pointed out that under current economic pressures there is a growing conviction that programs and courses with no direct relationship to productivity should not be supported. As a consequence, there is a decreasing interest in degree programs and a growing interest in more individualized education and training aimed at improved competence and performance on the job.

The sole industry representative on the panel, Mr. Donald Miller, IBM, stressed the need to shift our emphasis on education from institution-centered to student-centered, i.e. individually-centered education. He believes that growth and development of individuals is a logical outcome of business, just as logical as dollars and cents profit. Careers should be looked upon as sequential, overlapping with some portions of each career carried on into the next career, but also, each career requiring something new. He pointed out that education without a purpose, just like training or learning without a purpose, is a non-productive kind of thing.

The need for a national technical manpower advisory capability was addressed by Dr. VanValkenburg from an academic viewpoint and by Dr. Dean Gillette, Bell Laboratories, from an industrial view. Using the Bell Laboratories and AT&T as the focus, Dr. Gillette described the phenomenal demand for engineers which resulted from the expansion of the industry caused by customer demand and the development of new technologies. He pointed out that R&D-intensive industries are leading the nation—engineers and scientists can develop technology that will stimulate the productivity of the nation and increase the GNP. A rational national policy should stimulate and encourage industry to grow and be more productive.

The need was further stressed by Dr. VanValkenburg who advocated the stimulation of economic growth by steering new engineering talent into low R&D-intensive areas. There is a need to organize and exploit the discoveries and developments of science and engineering.

The Thursday evening program was devoted to four workshops integrating across the four days of the Conference and refocusing the presentations, discussions, and workshops on engineering manpower as it relates to Industry, Government, Academia, and the Technical Societies. Recommendations and views discussed during these four sessions were presented by the workshop leaders on Friday morning and again integrated into some of the remarks made by Dr. Cornelius Wandmacher who closed the Conference with a set of tentative *recommendations for action*.

The Conference reached a consensus that engineers are an important national resource but are not adequately recognized as such in government decision-making circles. It demonstrated that engineers from a wide variety of backgrounds can come together and discuss professional problems rationally, agree on the definition of the major issues, and even reach general agreement on what ought to be done. The Conference was viewed as meeting the objectives set out by the planning committee. The Recommendations for Action, as refined by the Engineering Manpower Commission, are included in this report and represent a major contribution of the Conference. The real success of the Conference, however, can only be measured in the future following the dissemination of the recommendations to responsible individuals in industry, government, the universities, and the technical societies, and the actions which are taken as a result of them.

The consensus of the conferees was that the Engineering Manpower Commission should take a leadership role in matters pertaining to engineering manpower, and it is anticipated that the Commission will assume a major role in the follow-up on these recommendations.

RECOMMENDATIONS OF THE CONFERENCE

Recommendations to Government

1. Establish a central focal point within the federal government with responsibility to work with the engineering profession in the development of national engineering manpower policies and to have general oversight over federal actions affecting the nation's engineering manpower resources. In this context, the engineering community should be understood to include engineers, technologists, technicians, and related applied scientists.

The conference was made clearly aware that there was no center of responsibility within the federal government for the consideration of problems affecting engineers and related technological personnel. Although the conferees had reservations about the extent to which any one agency, or even the federal government, should have the authority to develop and implement manpower policy at the national level, they were in agreement that a focal point within the federal government was absolutely essential and urgently needed. The new Office of Science and Technology Policy under consideration by Congress and the President appeared to be a logical agency to be assigned this responsibility. This recommendation must be taken in conjunction with others that follow bearing on the broad questions of national policy related to the application of technology and manpower in general.

2. Recognizing the difficulty of defining and achieving consensus on national engineering manpower policy, and the necessity of proceeding with important measures prior to the development of such consensus, the following basic guidelines should be followed:

a. Career decisions should be a matter of individual choice and not dictated by a central planning authority.

b. Appropriate information on both long term and short term manpower requirements should be gathered and analyzed in a dynamic manner as the basis for continuous forecasts, which should be widely disseminated for career guidance. The effectiveness of the guidance system should be subjected to continuous evaluation.

c. Career opportunities should be available to all independent of sex, age, color, creed, or national origin.

d. National policy should recognize that a healthy engineering community is vital to national strength and prosperity and serves as a stimulant to all sectors of the economy.

e. Extreme variations in demand for engineering manpower, resulting in cycles of over and under supply, should be minimized by more careful planning and assessment of the manpower impact of government actions.

f. National policies should incorporate provisions aimed at optimizing engineering manpower utilization, enhancing engineering competence, and preventing manpower obsolescence.

The foregoing guidelines are considered basic to the development and establishment of national engineering manpower policy, recognizing at the same time that specific policies and programs will require extensive discussion and reconciliation of the needs of all sectors of society. The conference particularly wished to make it clear that the engineering community did not deserve or expect more favorable treatment than other occupational groups. The primary concern is to recognize the importance of a strong engineering capability as essential to the national well-being.

3. Improve the collection, interpretation, and dissemination of engineering data by the cognizant government agencies. Data and projections need to be more carefully defined and properly coordinated for greater consistency and credibility.

This recommendation reflects the conclusion of most conferees that government data and projections concerning engineering manpower are often outdated and are liable to be based in part on non-uniform definitions, methodologies, or unrealistic assumptions that do not have the confidence of the engineering profession. Since these data are widely distributed and used by many people for manpower planning, deficiencies in the data can lead to incorrect actions. The conference was particularly disturbed by serious inconsistencies between the projections made by the Bureau of Labor Statistics and the recent findings of the National Science Foundation. Similarly, the gross deficiencies in census data as compared to the carefully screened post-censal study results are cause for serious concern. Timeliness of the data is another area where improvement is necessary. Significant improvement could be achieved by involving the users of the data more closely in the planning and operation of the data collecting programs, as noted in the recommendation that follows. It would be particularly useful to have an outside group such as the National Academy of Engineering make periodic, in-depth studies of the government's engineering manpower data programs and report on how they could be improved.

4. Establish formal ongoing arrangements between the government and the engineering profession to assure adequate input to decisions and programs having important implications for engineering manpower.

The previous recommendations cannot be effectively carried out unless mechanisms are established by which the engineering profession can participate in government decisions and programs affecting engineering manpower. Different arrangements will have to be made at appropriate levels in both the legislative and executive branches of the government to involve the engineering professional organizations in national decision-making and planning processes as well as in the implementation

of programs. The resources of the profession could make a major contribution to the solution of national problems if effectively brought to bear on the issues. Involvement of the profession must go beyond superficial contacts with a few individual engineers, a few professional societies or even the National Academy of Engineering. The channels of communication must reach broadly and deeply into the professional structure in order to involve individual engineers representing a wide variety of needs. Relationships of this nature would be preferable to direct political action on the part of organized segments of the engineering profession, which is seen as a possible alternative method of achieving an input to national decision-making.

5. Develop and implement a comprehensive national policy aimed at improving productivity and stimulating research and development in all sectors of the economy.

Although this recommendation does not specifically call for manpower action, the effects of productivity and R&D on engineering manpower are so important that manpower cannot be considered outside the broader context of national decisions affecting engineers. The specifics of such a policy must be developed by groups representing interests other than manpower, but the conference urges that the manpower implications not be overlooked or given only superficial attention. The programs sponsored cooperatively by the National Commission on Productivity and Work Quality and the Engineers Joint Council are an example of progress in this direction.

6. Support the efforts of industry and the engineering profession to improve manpower utilization and professional career development by providing appropriate tax incentives to employers, following enlightened policies in the management of federal employees, and incorporating appropriate provisions in government contracts.

This recommendation recognizes that employers, engineering societies, and individual engineers cannot achieve the objectives of better manpower utilization and professional development without government cooperation and assistance. The importance of the federal government's own personnel and contractual policies should not be underestimated. In addition, more realistic tax treatment is needed with respect to expenses incurred by employers and individual engineers in pursuing the recommended career development objectives.

7. Assign responsibility and authority for implementing manpower planning in specific programmatic areas to those government agencies having major program responsibilities involving engineering and technology, in order to minimize disruptive manpower effects when programs are expanded or terminated.

Most government agencies having cognizance over major programs of significant technological content have little or no explicit responsibility for assessing the manpower impacts of the programs or planning to minimize undesirable effects on engineering manpower. The Energy Research and Development Administration appears to be a conspicuous but very recent exception. Instances of the disruptive effects occurring when manpower considerations are not adequately handled may be cited from past aerospace and defense programs. Agencies with manpower development authority should be responsible for seeing that their plans are closely coupled with actual manpower needs, lest these lead to the overproduction of manpower in occupations where insufficient jobs exist. The best way to insure that manpower planning will be properly carried out is to incorporate the requirement in the basic legislation establishing major programs with a strong engineering and technological component.

8. Reshape the National Commission for Manpower Policy to explicitly include the special needs of engineering manpower, or else clearly establish that the Commission is not intended to address the problems of the engineering community.

The ability of the National Commission to deal effectively with engineering manpower problems is seriously questioned. The matters to which it is addressing its attention appear to have little direct relevance to the problems of engineers, and the engineering community is not adequately represented in its membership, to permit it to deal adequately with the specialized needs of highly educated and technically skilled manpower. It might therefore be preferable to assign this responsibility explicitly to the "focal point" agency recommended previously and clarify the Commission's charter accordingly.

9. Convene a panel of leaders from all appropriate fields, including but not limited to engineering and science, to conduct a "technology assessment" of national policies affecting engineering, science, and technology manpower, and to explore alternatives.

This recommendation is addressed to the Office of Technology Assessment of the U.S. Congress. The nation's policies or lack of same with regard to engineering and related manpower constitute what might be described as "social technology" and are fully as important as the other technologies being studied by the OTA. Since the nation as a whole is affected by the way in which its stock of engineering manpower is utilized, the assessment panel must include top talent from all appropriate disciplines. Such an assessment would serve to focus national attention on the problems and proposed solutions identified at this conference.

Recommendations to Employers

1. Devote serious management attention to improving the utilization of employed engineers, technologists, technicians, and applied scientists.

This general recommendation stems from widespread evidence of dissatisfaction and unmet expectations on the part of engineers, most frequently caused by the employment of engineers in unchallenging or sub-professional positions, failure of employers to make adequate provision for the career development of their engineers, job insecurity, and various forms of non-professional treatment. This dissatisfaction is being reflected in the withdrawal of engineers from the profession, pressure for action on the part of engineering societies by their members, and increased support of formal collective bargaining arrangements. Although the recommendation relates generally to management attention, some specific suggestions include the following:

a. Develop better ways to measure the capabilities of engineers and the extent of their utilization in typical work situations, in order to improve and optimize the factors involved.

b. Identify situations in which engineers are being utilized sub-professionally and initiate action to correct the conditions contributing to such situations.

c. Define more carefully the work functions and job levels expected of engineers, scientists, technologists, and technicians and see that these are properly articulated in the organizational structure.

d. Investigate the possibility of using more support personnel to assist engineers.

e. Take all feasible measures to smooth out fluctuations in hiring and termination cycles.

f. Provide opportunities for career growth in technical work as well as administrative or managerial positions.

2. Make continuing professional development a standard condition of employment for engineers by providing adequate time and facilities, during the working day or on compensatory time, for learning experiences of benefit to both the employer and the individual.

This recommendation reflects the serious concern that engineers too often find their careers terminated prematurely due to so-called obsolescence. In order for engineers to keep up with constantly changing technology, they must have the opportunity to pursue the means of career development. It is unrealistic to expect engineers to do this largely on their own time and at their own expense. Professional career development activities include formal education courses, on-the-job diversification, consultancies, participation in the activities of professional associations, educational and governmental internships, etc. The costs of continuing professional development must be accepted as one of the normal required expenses of doing business, since the benefits ultimately accrue to employers as much as to individual engineers. The establishment and pursuit of career development plans should take cognizance of both individual goals and company goals. Engineers should particularly be informed of career implications involved in the choice between managerial and technical job opportunities.

3. Eliminate barriers to the hiring or reassignment of older engineers.

Much of the basic knowledge and technical skill of engineers is transferable among different job functions and kinds of products, often with relatively little refresher training or reorientation. Employers should wherever possible avoid simultaneously laying off older engineers while hiring new ones, but should make every effort to reassign personnel. Unemployed engineers should not be barred from consideration for employment solely on the grounds that their former association with other industries or specialties might be inappropriate to the new job. Management should make a conscious effort to discover and eliminate subtle barriers to employment such as overly restrictive job qualifications, internal accounting procedures that discourage departments from accepting transferred personnel, or prejudice against engineers previously employed in the aerospace industry, for example. Problems encountered by engineers in making mid-career transitions are a major cause of bitterness and dissatisfaction among older engineers, and are reflected in concerns expressed by younger engineers and students.

4. Promote the interchange of information and experience between employers and educational institutions.

The quality of engineering education is of continuing concern to employers, educators, and students alike. Faculty and students need to be kept abreast of industrial methods, employer needs, and conditions in engineering practice. Industry can also provide resources of expertise, facilities, and real problems for use by educational institutions. Contacts of this kind require action on the part of educators as well, and this is the subject of a separate recommendation addressed to education.

Recommendations to Educators

1. Modify programs and curricula to preserve students' flexibility as to field of engineering or commitment to a specialty as late as possible in the educational process, in order to minimize the mismatch between manpower supply and demand when students leave the universities.

The demand for engineers is subject to strong and sudden fluctuation due to factors that cannot be controlled by educational institutions. It is therefore desirable that students be afforded the maximum opportunity to shift field or specialty in response to employment demand. If educators recognize the importance of this, they can adjust curriculum and degree requirements to build in more flexibility than is currently the norm.

2. Improve mechanisms for the interchange of information and experience between educational institutions and the practicing profession.

This is the counterpart of recommendation number 4 to employers, and it reflects the concern that unnecessary barriers exist within the educational establishment against the participation of the practicing profession in the educational process. Among such perceived barriers are credentialism, reluctance to change, preconceived notions about the proper role of engineering, and various restrictive administrative practices. The constant interchange of information and experience between education and professional practice is essential to the health of the engineering profession and is a two-way street which both parties must be willing to travel.

3. Communicate to students in high school and the beginning years of engineering college a realistic view of the nature of engineering work, engineering opportunities in coming years, and especially the need for continuing learning and flexibility in skills and attitudes to adapt to changing technologies in the course of an engineering career.

This recommendation is intended to emphasize the need for continuing and realistic career guidance in the pre-college and college years. The focus is on guidance of students so that they can make informed career choices and avoid unrealistic expectations, rather than on recruitment. Guidance is seen as the most important use of manpower data and interpretive information on the part of educators. Much information is available from groups like the Engineering Manpower Commission, but improvements are also needed as noted in some of the recommendations to the engineering profession.

4. Promote awareness and understanding of political and economic factors on the part of engineers by providing appropriate information and encouraging experience for both faculty and students.

Political and economic decisions have been shown to have controlling effects on engineering employment and professional practice. Little effort seems to have been made to incorporate an understanding of these factors in the education of engineering students, with the result that engineers tend to be naive or unaware of the importance of such matters. In addition to simply informing students that politics and economics are relevant to engineering, colleges should encourage both students and faculty to participate in Congressional fellowship programs, government advisory committees, and the national decision-making process generally.

5. Continue to provide diversity in the form of a wide spectrum of high quality engineering and technology programs.

A major strength of engineering and technology education is its diversity. While this should be encouraged, the maintenance of quality in all programs is equally important. Care should be taken to differentiate between engineering programs and technology programs in terms of their different career prospects. The two types of programs should be monitored continuously to guide balanced growth of both.

6. Devote special effort to encouraging the participation of women engineers in the educational process.

The growing numbers of women engineering students make it especially important that the input of practicing women engineers be encouraged. This objective should be pursued in addition to the general interchange discussed in recommendation number 2. The number of women engineers holding doctorates is very small, so special efforts will be required to involve others on the basis of talent and competence.

7. Devote special effort to encouraging the involvement of minority engineers in the educational process.

In recognition of the fact that minority groups and women face different problems in the educational process, special attention must be given to each group. As increasing numbers of minority students enter engineering programs, it is important that effective input be provided from talented minority members of the practicing profession.

Recommendations to the Engineering Profession

1. Central to all of the other recommendations which follow, the engineering societies should seek to establish a unified organization in which responsibility for particular functions could be clearly identified and concentrated.

The engineering profession is at a great disadvantage in seeking to have its views given serious attention by the government because its potential strength is scattered and dispersed. Similarly, its data collection and public information efforts are fragmented and often ineffectual. In the absence of unified action by the profession, the more specific problems involving engineering manpower are unlikely to be solved. These include, but are not limited to, the establishment of conditions necessary for effective utilization and professional development of engineers, the establishment of adequate data collection programs, the more explicit identification of engineering as a key factor in national decison-making processes, the enhancement of public awareness and understanding of engineering, and the development of a unified code of ethics to provide a cohesive base for self-regulation of the profession.

2. Develop and support comprehensive programs to enhance the continued professional development of engineers.

This recommendation is addressed to each engineering society on behalf of its individual members and to joint organizations on behalf of the profession. Programs

should include the collection and dissemination of manpower data relevant to career planning, the development and support of continuing education courses, and the fostering of policies and practices to facilitate professional development. It was also suggested that the societies should consider setting up an agency to accredit the career development programs of employers on the basis of factors such as continuing education, utilization practices etc.

3. Make individual engineers more aware of their personal responsibility to grow and develop throughout their professional careers.

Other recommendations have focused on actions to be taken by employers, educators, and the government, but successful career development also requires individual initiative and commitment. Engineers must continuously analyze their strengths, weaknesses, and professional needs in order to have influence on the nature and quality of their work. The engineering societies must play a strong role in emphasizing the importance of this responsibility on the part of their members, and by providing realistic career guidance information to students and engineers at all stages of professional development.

4. Improve the collection and dissemination of manpower information within the engineering profession in the following particulars:

a. Devote more effort to producing reliable information on manpower supply and demand, and the modeling of future needs.

b. Improve the coordination of manpower activities conducted by the various engineering societies.

c. Do a better job of interpreting manpower data from all sources and reducing the information to forms best usable by educators, manpower planners, and individual engineers.

This recommendation addresses itself to the areas of greatest perceived weakness in the manpower programs of the engineering societies and their joint organizations. Better information on future manpower needs was felt particularly required by educators so that they could coordinate the kinds of programs offered, eliminate undue duplication, and avoid producing an over or under supply of graduates. The concept of a "relative demand index" was considered promising and worth developing.

It was suggested that the Engineering Manpower Commission be given a greater role in cooordinating the efforts of the societies by, for example, developing some standards for manpower data collection. EMC might also be designated as the agency responsible for synthesizing the data and analyses produced by other research groups and putting them into forms best suited to use within the profession. The conference particularly noted that manpower information should not be produced solely for the benefit of researchers, but should be gotten into the hands of people in a position to make practical use of it.

5. Develop ways to measure more concretely the contribution of engineers toward productivity, technological growth, and the national economy.

Although many speakers emphasized the importance of engineers to the national economy, it was evident to the conference that little hard data could be found explicitly measuring the contribution of engineers. Engineers believe that they play a key role in our technological society and are responsible for a large part of the nation's economic gains. However, people who do not understand the technological process fail to recognize the importance of engineering. If engineers are to be given credit for their economic contribution to national well-being, they must find ways to measure and report this contribution in tangible economic terms. The profession itself must take the initiative to encourage industry and government in developing the necessary data for this purpose.

6. Encourage and support the involvement of engineers in the political and economic decision-making process.

Since engineers are so directly affected by political and economic decisions, it is to their interest to have a stronger voice in the processes by which such decisions are made. For example, if inappropriate policies are adopted regarding energy utilization, ecological standards, safety and health specifications, and equal employment opportunity activity, these could be unproductive and wasteful of engineering and technical talent. Existing efforts on the part of the engineering societies were viewed as lacking in political "clout". Suggestions were even made that the profession consider encouraging engineers to run for public office. This recommendation obviously has implications beyond strictly manpower considerations, but the conference felt that the profession's manpower problems could not be solved in isolation from broader national issues. A similar recommendation relating to the educational system is offered as recommendation number 4 to educators.

7. Encourage public and professional awareness by emphasizing the use of the term "engineering"; instead of "science and technology", use "engineering and science" or "engineering, science, and technology".

The conference noted a persistent tendency for "science and technology" to be used instead of a more explicit identification of engineering in government pronouncements, the press, and even within professional circles. This practice contributes to the lack of recognition and understanding of engineering on the part of the general public.

8. Continue to support and encourage efforts to increase the proportion of women in the engineering profession.

The conference whole-heartedly endorsed the objective of equal opportunity for women in engineering. Current programs toward this end should be supported regardless of other manpower problems faced by the profession. A suggestion was made that the Engineering Foundation sponsor a conference in 1976 on professional development for women engineers. This is heartily supported as a specific contribution toward carrying out the intent of this recommendation.

9. Continue to support and encourage efforts to increase the proportion of minorities in the engineering profession.

The conference whole-heartedly endorsed the objective of achieving parity of representation for minority members in engineering. Programs toward reaching this goal should be supported regardless of other manpower problems faced by the profession. The problems involved in the minority effort were recognized as being different from those of the women's program, and both objectives should be pursued independently.

PART II

Summary of Remarks by Dr. Myron Tribus
Director, Center for Advanced Engineering Study, M.I.T.

The real challenge for this conference is to decide where we wish the engineering profession to stand, rather than just where we are today. Four principal problems have to be considered before deciding what stand to take:

1. A vacuum in technological planning at the national level;
2. A failure in academia to comprehend the real nature of engineering;
3. National policies inadvertently causing a decline in the productivity of labor, capital, and technology itself;
4. The absence of people with engineering training from centers of power and decision-making in our society.

Technological planning requires the identification of important national goals stated as specific, quantifiable objectives. These must then be expressed in terms of the resources required to meet the objectives, and their consequences must be studied. The nation does not have the resources to achieve all objectives simultaneously, so plans must be adjusted. Most problems require cooperative action by both the public and private sectors, but the government has the responsibility for studying, planning, and setting national goals. To date the only agency set up to do this kind of planning is the Energy R&D Agency (ERDA). However, we have not carried out the institutional reforms necessary to follow up the plan, or to conduct planning in other areas. A major consequence of this lack of planning is our inability to solve our manpower problems.

With regard to academia, it teaches engineering as a set of scientific, analytic disciplines in which human values are suppressed. Industry on the other hand is organized in terms of doing things, while the interface with society is concerned with the functions for which technology is needed. The academic approach fails to take adequate account of industrial needs and human values and therefore does not prepare students fully for real engineering work.

Productivity invariably declines as materials, energy, and labor grow scarcer or more expensive unless technology is applied to raise efficiency. Today, because of various governmental actions that have made it more difficult and more expensive to put technology into use, the productivity of technology has been lowered. There are many areas where national productivity can be improved. These fall into four combinations of old or new technology with old or new applications, which involve different levels of technical and market risk. Opportunities for engineers exist in all four areas, but the implications in terms of educating engineers and encouraging their employment in the different modes of operation have received little attention.

There has been a serious erosion in the self-image of engineers. Many people believe that technical obsolescence and mid-career employment difficulties stem from the style of management common in our modern industrial society. The subdivision of engineering work and lack of attention on the part of managers to the career development of their engineers have made it increasingly difficult for engineers to see themselves as members of a profession. The French have made it a legal requirement for employers to set aside part of the payroll to support continuing education so that their society will be able to adapt to the rapid changes that are inevitable in the future.

U.S. engineers today do not have the ability to influence the policies that have produced our problems. Rather, they have been taught to shun power and to consider political action inappropriate. Because there is little sense of unity among engineers, it is unlikely that the present generation will be able to develop political strength or clout. Younger engineers and students are showing a growing awareness of the problem, but time is short and the obstacles to change are many.

The conference should address itself to these key issues, define its objectives, and decide what we want to do about overcoming the problems and reaching the goals desired by the engineering profession.

Summary of Remarks by John D. Alden
Executive Secretary, Engineering Manpower Commission of Engineers Joint Council

Note: The complete text of Mr. Alden's paper is included in Part III of these Proceedings.

Although there has been a resurgence in interest and activity within the engineering profession with respect to manpower utilization, most of it has been oriented toward the members of particular societies. It is impossible to gain a comprehensive overall picture of engineering manpower from these uncoordinated activities. The Engineering Manpower Commission carries out profession-wide surveys in a limited number of areas, examples of which are available for conferees to review.

Taking an overall look at the manpower picture today, the situation in industry with respect to engineering employment is chaotic. Demand has been fluctuating wildly for the last five years, and the job market worsened seriously last winter. Employers have curtailed their hiring plans. Although some industries and some specialties report manpower shortages, the overall picture is one of retrenchment and uncertainty about the future.

Fluctuating employment prospects resulted in successively lower enrollments in engineering schools, until an upturn last fall. The supply of graduates will be smaller than usual for the next few years. Qualitatively, the schools are criticized by employers for not producing the kinds of engineers industry wants. The picture has been complicated by the emergence of four-year technology programs. Educators too are uncertain about the future.

Individual engineers are concerned because of rising unemployment, and feel that they have little say over their own destiny. They are putting increasing pressure

on their professional societies to do something about their problems.

Engineers feel that the government has come to see them as just another pressure group rather than as a national resource. They do not feel that government is effective in introducing sound technical advice to the national decision-making process.

The engineering profession itself is so fractionated and loosely organized that most engineers do not understand how the various societies are related to each other. Half of all engineers do not belong to any society. Congress, the press, and the public are unable to tell one group from another. Consequently the voice of engineering is a Babel of confusing tongues.

It is not inevitable that we stay where we are today. The conclusions and recommendations of this conference will help to determine and reach new goals.

Summary of Remarks by Dr. Charles E. Falk Director, Division of Science Resources Studies, National Science Foundation

It is important to view the characteristics of engineers within the perspective of the total U.S. or the science and engineering labor forces.

Because engineers represent only about one percent of the work force, there are some issues such as unemployment where they cannot expect an undue share of consideration. In relation to the effectiveness of the U.S. technological effort, however, engineers obviously deserve significant consideration. Within the science and engineering population, engineers make up nearly 65% of the total. (Figure 1.) A comparison of the characteristics of the two groups (Figures 2,3,4) indicates significant differences between them. Consequently, for technical manpower policy development, the two groups should not always be examined as a single unit but frequently should be disaggregated in order to identify and solve different manpower problems.

Unemployment rates of scientists and engineers can be compared with various other national unemployment rates. (Figure 5.) Both engineers and the professional/technical group of which they are a part show considerably lower unemployment than the total labor force. A related aspect involves the fraction of engineers not engaged in science or engineering-related activities. (Figures 6,7.) Most of these are there voluntarily because of better salary, greater promotion opportunity, and similar reasons. Underutilization is probably also a problem, but one that is difficult to define and measure.

The supply of engineers involves two aspects: the nature and quality of engineering education and the magnitude of the graduating classes. The number of engineering graduates has grown much more slowly than science graduates. (Figures 8,9.) Enrollments in both science and engineering have been declining in recent years. (Figures 10,11.)

Projections of future manpower needs are hazardous because the art of forecasting is relatively crude. Good forecasts frequently tend to be self-defeating because they persuade people to change their course of action. They should not be viewed as predictions of the future but as models which show the likely effects of different assump-

ENGINEERS IN RELATION TO VARIOUS ELEMENTS OF THE U. S. LABOR FORCE

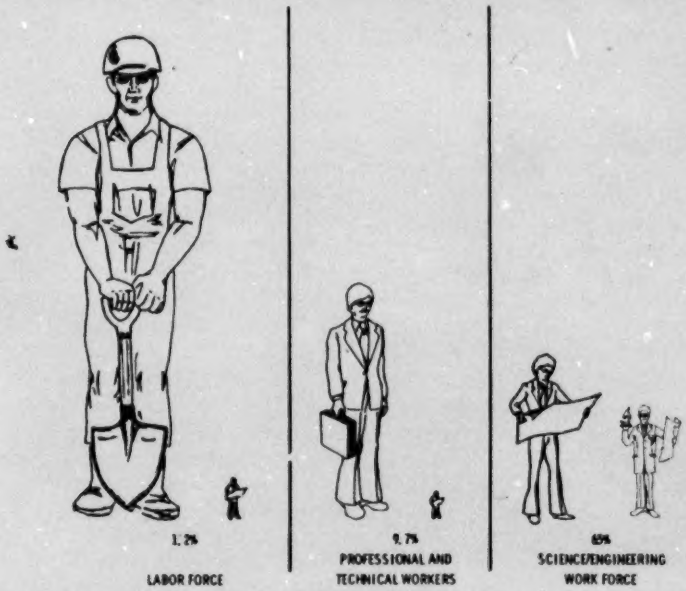
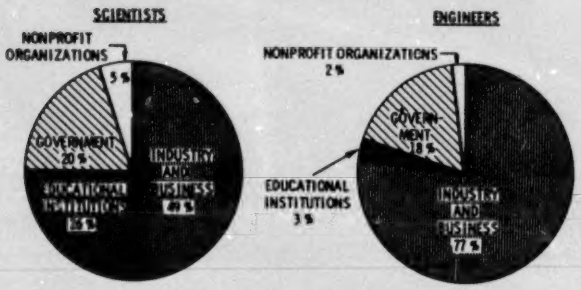


FIGURE 1

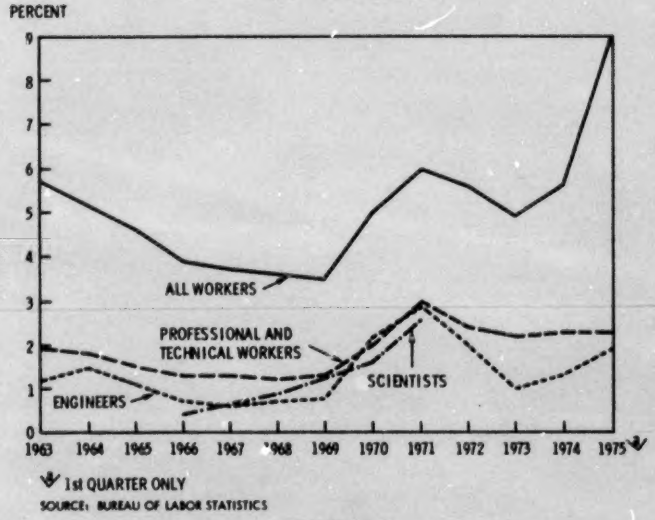
SCIENTISTS AND ENGINEERS BY TYPE OF EMPLOYER, 1974



SOURCE: NATIONAL SCIENCE FOUNDATION (NATIONAL SAMPLE)

FIGURE 2

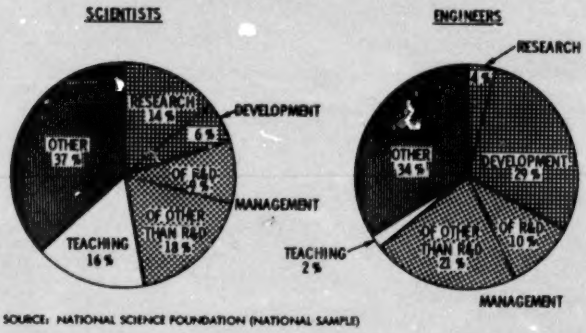
UNEMPLOYMENT RATES, 1963 - 75



SOURCE: BUREAU OF LABOR STATISTICS

FIGURE 5

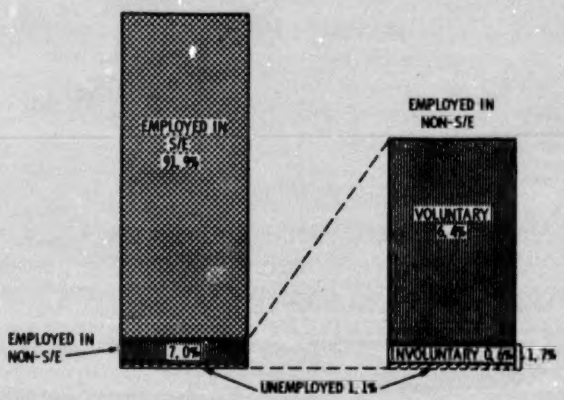
SCIENTISTS AND ENGINEERS BY PRIMARY WORK ACTIVITY 1974



SOURCE: NATIONAL SCIENCE FOUNDATION (NATIONAL SAMPLE)

FIGURE 3

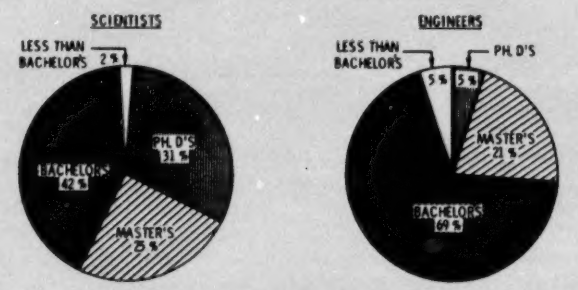
SCIENCE/ENGINEERING LABOR FORCE, 1974



SOURCE: NATIONAL SCIENCE FOUNDATION (NATIONAL SAMPLE)

FIGURE 6

SCIENTISTS AND ENGINEERS BY HIGHEST DEGREE, 1974

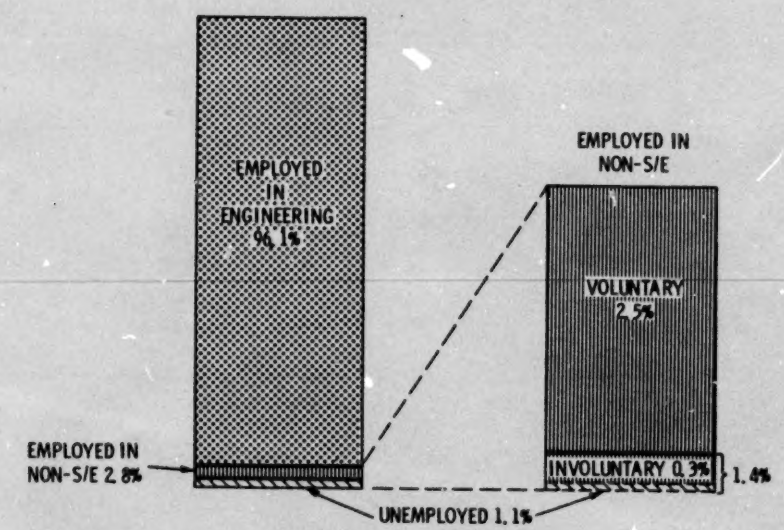


SOURCE: NATIONAL SCIENCE FOUNDATION (NATIONAL SAMPLE)

FIGURE 4

tions about the factors involved. Two major overall forecasts of engineering supply/demand have been produced. The Bureau of Labor Statistics study of 1974 involves rather optimistic assumptions such as 4 percent annual growth in real GNP, an unemployment rate of 3 percent, etc. BLS foresees supply falling 4 or 5 percent short of demand for 1,500,000 engineers by 1985. A modified projection by Roger Bezdek published by IEEE, using basically the same methodology as BLS, showed variations of 2 to 4 percent in total requirements depending on which of three national spending scenarios was used. If present conditions continue, overall future shortages are unlikely.

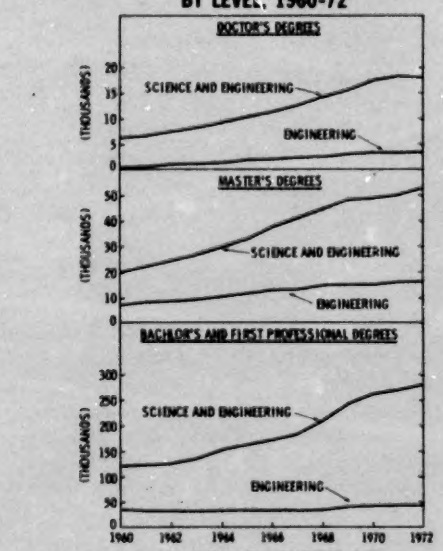
ENGINEERING LABOR FORCE, 1974



SOURCE: NATIONAL SCIENCE FOUNDATION (NATIONAL SAMPLE)

FIGURE 7

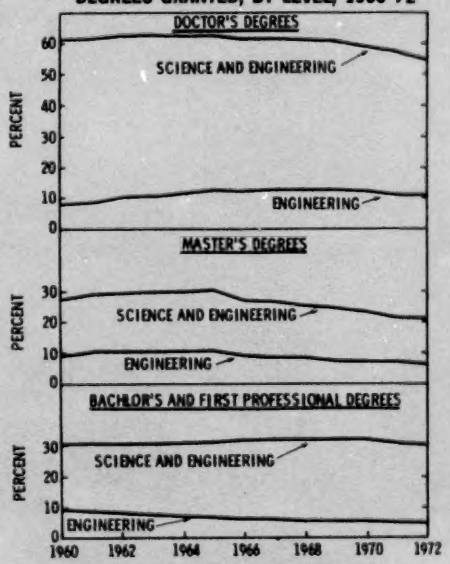
NUMBER OF SCIENCE AND ENGINEERING DEGREES GRANTED, BY LEVEL, 1960-72



SOURCE: NATIONAL CENTER FOR EDUCATION STATISTICS, DHEW

FIGURE 8

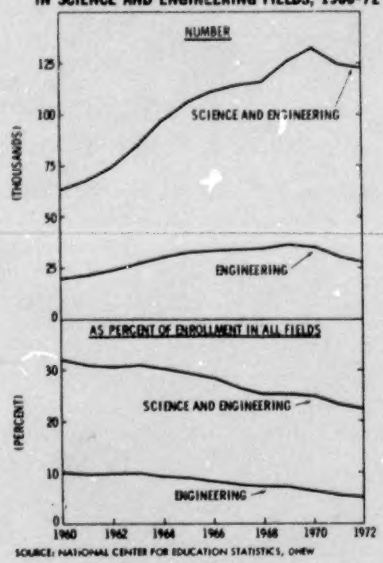
SCIENCE AND ENGINEERING DEGREES AS PROPORTION OF ALL DEGREES GRANTED, BY LEVEL, 1960-72



SOURCE: NATIONAL CENTER FOR EDUCATION STATISTICS, DHEW

FIGURE 9

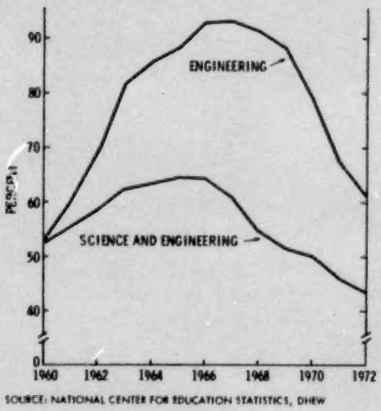
TOTAL FIRST-YEAR ENROLLMENT FOR ADVANCED DEGREES IN SCIENCE AND ENGINEERING FIELDS, 1960-72



SOURCE: NATIONAL CENTER FOR EDUCATION STATISTICS, DHEW

FIGURE 10

FIRST-YEAR ENROLLMENT FOR ADVANCED DEGREES IN SCIENCE AND ENGINEERING FIELDS AS PROPORTION OF PRIOR YEAR BACHLOR'S AND FIRST PROFESSIONAL DEGREES IN SAME FIELD,1960-72



SOURCE: NATIONAL CENTER FOR EDUCATION STATISTICS, DHEW

FIGURE 11

SCIENCE AND ENGINEERING MANPOWER REQUIREMENTS FOR MAXIMUM U.S. ENERSY EFFORT, 1970, 1980, AND 1985

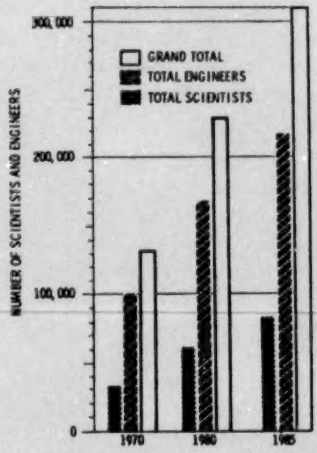


FIGURE 12

PROJECTED EMPLOYMENT REQUIREMENTS FOR SELECTED FEDERAL POLLUTION CONTROL AND ABATEMENT ACTIVITIES, BY SELECTED OCCUPATIONS, 1980

SELECTED OCCUPATION	RESEARCH AND DEVELOPMENT	WASTE WATER TREATMENT PLANT CONSTRUCTION
TOTAL	14,140	179,510
PROFESSIONAL AND TECHNICAL	6,260	26,030
ENGINEERS	1,440	8,080
NATURAL SCIENTISTS	2,790	360
TECHNICIANS	1,654	9,690

SOURCE: BUREAU OF LABOR STATISTICS

FIGURE 13

In considering the future, NSF estimates an average annual growth of about 1.5% in R&D spending (constant dollars) for the next decade. New programs such as the space effort have had major impacts in the past. Most projections do not make explicit assumptions about new national thrusts, but studies of possible technical manpower needs for energy development and pollution control indicate that the relative impacts of single programs are not particularly large. (Figures 12,13.) The maximum energy scenario, for example, would require about 8,000 additional engineers per year, or about 12% of the expected master's and bachelor's degree production.

This overview is intended to provide some indications of the current manpower picture and possible future trends as a basis for consideration by the conference.

Summary of Remarks by Mr. Norman Harvey Manpower Administration, U.S. Department of Labor

The major programs of the Manpower Administration which directly benefit engineers are the Unemployment Insurance program which provides payments to eligible unemployed workers and the Employment Service which offers job finding assistance. All openings listed by employers with the public employment service are now entered in a computerized job bank. Summaries of these job bank listings which indicate job openings throughout the country may be consulted in local offices in major cities. Despite the recession, there were 6,900 engineering and architectural jobs available in April 1975, down from 13,800 a year earlier.

During the employment downturn in 1970-71, the Labor Department also developed a number of special programs to assist unemployed engineers, technicians, and professionals. This special effort included job placement workshops, a national registry of engineering jobs and applicants, special employment units, a skill conversion study, a relocation assistance program and several retraining programs. The techniques employed in these programs are available for use if the unemployment situation for professional and technical workers should again warrant such action.

Summary of Remarks by Paul J. McGrath Director of Placement and College Relations, General Motors Corporation

General Motors review of manpower matters begins with an annual detailed inventory of the college graduate population within GM, showing where they were employed, where they came from, and how they were being utilized. The population base is about 40,000, of whom 55% hold technical degrees. In comparison with the personnel structure that existed in 1956, the total college population has doubled and the number with master's degrees has quadrupled. Since 1956, the percentage of graduates with engineering degrees has slightly decreased while the percentage of business graduates has risen.

The inventory reflected that engineering graduates were being used in positions where an engineering degree may not be necessary, such as manufacturing and other areas. We are reviewing this quite carefully.

The incoming stream of college graduates for one recent year was made up of inexperienced graduates – 56%, experienced graduates – 18%, co-op students – 6%, and graduates of General Motors Institute – 20%.

In order to estimate future needs the company has developed a mathematical model that projects the numbers and kinds of college graduates needed in order to achieve the desired management goals.

The Human Resources Management (HRM) system at GM includes seven elements, as follows:

1. *Inventory.* The Human Resources Inventory is the organizational procedure for surveying and recording the relevant data on all employees with emphasis on easy storage, retrieval and maintenance of that data.
2. *Appraisal* involves the evaluation of employees in terms of their job performance, potential for advancement, and other characteristics. This helps to establish better communications with employees and facilitates the improvement and development of their job performance and capacity for advancement. It also provides better knowledge of the depth and quality of organizational human resources, and assists in better decision making on compensation, selection, manpower planning, and other questions.
3. *Forecasting* is the organizational process of projecting from known historical data those opportunities that will be filled both from internal and external sources.
4. *Selection* is the organizational process by which the qualifications of various candidates for a position are evaluated and a decision is made to offer the position to one of the candidates.
5. *Acquisition.* The acquisition process is the means by which organizational needs for qualified employees can be filled by interdivisional transfers and/or new hires. In general, the acquisition process is oriented toward filling positions of greater responsibility than typical entry-level jobs. It is intended to place special emphasis on identifying and placing qualified minority and women candidates.
6. *Development.* A developmental system is the organizational means of effecting personal growth and change among employees in order to improve their job performance and capabilities and to prepare them for more responsible assignments.
7. *Career Planning* involves the establishment of plans for the development and advancement of employees, using appraisal, inventory, forecasting, and other types of human resources management data. Career Planning has the objectives of: (1) assuring an adequate supply of ready managerial talent for the Corporation; (2) managing the development and mobility of capable employees; (3) providing the maximum opportunity and consideration for employees.

Summary of Remarks by Harold J. Ammond Executive Secretary, Association of Scientists and Professional Engineering Personnel

Industrially employed engineers and scientists are showing deepening concern because of total lack of job security, reduced salaries due to cost of living increases, salary compression, lack of effective merit review programs, and unpaid overtime work.

There has been increased organizing activity on the part of engineers during the last three years, with the Worthington CEI, Aerospace Corp., and Ford Motor Company Engineers organizations having been formed. Groups also initiated organizing activities at the AIL Corp., Lockheed Plainfield, and Knolls Atomic Laboratories. During the last month the 3,000-man McDonnell Douglas Engineers union, formerly independent, joined the Teamsters Union and 1,200 Convair engineers joined the UAW's newly created National Engineers and Professionals Association Division. Major organizing efforts are underway by the NEPA/UAW at North American Rockwell and by the Teamsters at Hughes Aircraft, both in Los Angeles. NEPA/UAW is also trying to organize at Lockheed Sunnyvale. Various Western Electric plants are being organized by the IBEW.

The success of the UAW and Teamsters in unionizing engineers presages strong competitive efforts on the part of the AFL-CIO as well as these unaffiliated unions. This is the first time engineers have proven willing to join these large blue-collar unions, which indicates a significant change in attitude. The concerns of industrially employed engineers have been studied, surveyed, and reported on in the past. Now engineers are taking strong positive action to correct situations that the professional societies have been unwilling or unable to handle.

Summary of Remarks by Bryce I. MacDonald Director of Engineering, Kennecott Copper Corporation

The concerns of engineers differ depending on whether they are young or old, supervisors or not, etc. and their concerns change with time. Concerns depend on two things: expectations and values. Engineers who grew up earlier than the 1940's expected little more than steady employment and their values were influenced by the depression and world order of the time. Since World War II the nature of engineering has changed greatly, young engineers have greater expectations, and their values are more material-oriented.

Today the leadership of the profession is largely in the hands of older engineers whose values and expectations are not shared by the younger members. Differences exist in the approach of the two groups in compensation, financial security, job challenge, personal recognition, political impact, and professional ethics. Older engineers have a great responsibility to understand the needs of younger ones without being colored by their own value judgments and expectations.

As we look ahead 10-20 years, it is probable that big government will have gotten bigger, economic regulation of industry will have increased, and academic institutions will be more heavily subsidized by the state. At the same time, the need for engineering work will be greater than now. It follows that a larger fraction of engineers will be employed by the government.

In the past engineering was primarily concerned with design. Now and in the future engineers as we know them today will be engaged in four different kinds of work: doing research; making studies; designing, building, and operating; and teaching. It will probably become more difficult to switch from one type of work to another. In response to this diffusion, the definition of engineer is likely to be narrowed and regulated by licensure.

As older engineers retire, the concerns of today's younger engineers 10-20 years from now will probably change in these directions:

- compensation will become less of a concern because increased regulation and organized bargaining pressure will stabilize salary differentials;
- financial security will be as much of a concern as it is today;
- conditions of employment will be more formalized;
- engineers will be less concerned with personal recognition and will seek satisfaction away from the job;
- they will have organized themselves to exert political influence;
- problems of professional ethics will build up to a crisis like that being undergone by the medical profession.

What the concerns of the younger engineers of the future will be, no one can tell.

Summary of Remarks by Naomi J. McAfee Director of Reliability, Quality, Maintainability, and Safety Engineering Activities Westinghouse Defense and Electronics Systems Center

Women engineers share the same concerns as men with regard to their careers. They wonder whether projections for the future are realistic, and they want to know how one can shift fields when the demand for engineers changes from old technologies to new ones. Women engineers, like members of the minority groups, also have special concerns. Today they are starting to worry about reverse discrimination because of the strong pressures on employers to provide equal opportunities. Women engineers want to compete on an equal basis with men, not to receive undeserved favoritism. At the same time they are concerned that some of the attention being given to them may be tokenism. They want work that will lead to real career development, not highly visible token jobs. Finally, they are still having to overcome old prejudices and attitudes left over from the days when engineering was stereotyped as an excusively male profession. Although these old prejudices are breaking down, they still constitute a problem that many individual women engineers must contend with.

Summary of Remarks by Dr. Roger M. Zimmerman Professor of Civil Engineering, New Mexico State University

Note: The complete text of Dr. Zimmerman's address is included in Part III of these Proceedings.

Several concerns have not been addressed yet at this conference. The first involves the image and identification of the engineering profession. The majority of engineers work as employees, largely in industry, and have employment patterns that are dissimilar to other organized professions. Only about a third of all U.S. engineers are registered as PE's and even fewer belong to NSPE. As employees, engineers are starting to take on the actions of the public school teachers.

Another concern is the role being taken by engineering technology. Statistics show that this group is growing rapidly, and could have a significant impact on the number of engineers graduated. Technicians and technologists should be considered as part of the engineering manpower picture.

A third concern relates to the erosion of engineering talent through early career termination. The problems are real, but a way other than collective bargaining should be found for dealing with them. It is proposed that we set up an accreditation procedure for industry designed to evaluate employers' career development programs. This would be an attraction to graduates and a significant help in their careers as engineers.

Summary of Remarks by Warren E. Alberts Vice President — System Operations Services, United Air Lines, and President, EJC

The subject of productivity has been receiving increased attention nationally. Much of the material to follow was presented by noted economists at a conference sponsored jointly by Engineers Joint Council and the National Commission on Productivity and Work Quality.*

Economic growth comes both from having more workers and more output per person. Since 1950 the U.S. real GNP increased by 131%, while the number of people employed grew by 46% and output per worker grew by 58%. Thus most of the growth can be attributed to increased productivity. A good example is agriculture, where output per man-hour rose by 268% from 1950 to 1967, while the number of farmers decreased by 57%. Productivity increase came about through advances in science and technology, better tools, and management changes such as larger farms and other economies of scale.

In comparison with other countries, the U.S. rate of growth in GNP and in manufacturing productivity has fallen far behind. (Tables 1,2.) This has adverse implications for our standard of living because of industry's reduced competitiveness in foreign and domestic markets, the nation's reduced ability to combat inflation, and increased pressure for redistribution of income from a slower growing GNP. Confirmation of our decreasing ability to compete is shown in unfavorable trade balances in minerals and fuels, non-technology-intensive products, and raw commodities, and in a reduced balance in technology-intensive manufactures since 1965. Only in agricultural products do we still show a favorable trend. (Table 3.) Trends in R&D effort (Table 4) give some insight into the decline in competitiveness. The growth rate of R&D has decreased steadily since 1957 and has actually become negative in recent years.

Many economic scholars, including Edward Dennison and Robert Solow, have developed statistics showing that technological or engineering changes are the primary cause of productivity growth. (Table 5.) It would be useful for each engineering discipline to identify specific examples of technical advances in its own field, their impact on productivity, and the source and motivation

Table 1

RATE OF GROWTH (GNP Per Civilian Person Employed, % Per Year)

COUNTRY	1870–1980	1950–1965	1965–1971
UNITED STATES	2.4	2.5	1.3
WEST EUROPE (AV.)	1.5	4.0	4.3
U.S.S.R.	1.7	4.2	4.3
JAPAN	1.4	6.8	9.6

Table 2

PRODUCTIVITY GROWTH IN MANUFACTURING (% Per Year)

COUNTRY	1920–1960	1960–1965	1965–1972
UNITED STATES	3.1	4.3	2.4
E.E.C. COUNTRIES (AV.)	–	5.9	5.9
UNITED KINGDOM	–	4.0	4.7
CANADA	–	4.3	4.8
JAPAN	–	8.5	11.6

*Proceedings, Conference on Productivity Through Engineering, May 1975, Engineers Joint Council, 345 East 47th St., New York, N.Y. 10017. Price $10.

Table 3

U. S. TRADE TRENDS
(Billions of Dollars)

	1951–1955	1965	1972
AGRICULTURAL PRODUCTS			
EXPORTS	3.2	6.2	9.4
IMPORTS	4.4	4.1	6.2
BALANCE	– 1.2	2.1	3.2
MINERALS, FUELS AND OTHER RAW MATERIALS			
EXPORTS	1.3	2.6	4.3
IMPORTS	3.3	5.4	10.1
BALANCE	– 2.0	– 2.8	– 5.8
NOT TECHNOLOGY INTENSIVE MANUFACTURED PRODUCTS			
EXPORTS	3.7	4.4	7.1
IMPORTS	1.9	7.4	17.8
BALANCE	1.8	– 3.0	– 10.7
TECHNOLOGY INTENSIVE MANUFACTURED PRODUCTS			
EXPORTS	6.6	13.0	26.6
IMPORTS	0.9	3.9	19.9
BALANCE	5.7	9.1	6.7
ALL COMMODITIES			
EXPORTS	15.5	27.5	49.8
IMPORTS	10.9	21.4	55.6
BALANCE	4.6	6.1	– 5.8

Table 4

INDUSTRIAL R & D EFFORT*
(Average Growth Rate in %)

	FINANCED BY FEDERAL GOV'T.	FINANCED BY PRIVATE COMPANIES	TOTAL
1953 – 57	25.5	9.4	15.7
1957 – 63	6.3	5.6	5.9
1963 – 69	– 0.8	5.1	2.4
1969 – 71	– 10.1	1.4	– 3.0

*IN TERMS OF EMPLOYMENT OF R & D SCIENTISTS AND ENGINEERS

Table 5

SOURCES OF PRODUCTIVITY GROWTH
(GNP Per Person Employed, 1929 - 1969)

DENISON's ESTIMATES		SOLOW's ESTIMATES	
CAPITAL PER WORKER	11.3%	CAPITAL	11.3%
EDUCATION PER WORKER	21.0		
ECONOMICS OF SCALE	17.9	NEW TECHNOLOGY	85.1
ADVANCES IN KNOWLEDGE	46.2		
ALL OTHER FACTORS	3.6	OTHER FACTORS	3.6

that brought the advance about. Such information should be made better known to engineers, the government, and the public.

A useful approach to improving productivity is to study the allocation of technical effort in terms of man-hours and dollars devoted to three levels of improvement. Level 1 consists of optimizing existing systems, and improvement can be realized in weeks. Level 2, which takes months to achieve, involves improving present systems, products, and processes. Level 3, the development of new systems, products, or processes, takes years of effort. Once the allocation of effort has been identified, steps can be taken to select and reach a new balance through appropriate management action.

Productivity growth can be achieved most readily when all groups work as partners toward accepted economic goals rather than as adversaries. Anti-business sentiment has been prevalent in some parts of government, labor, the press, and academia. If the U.S. is to regain its economic momentum, some way has to be found to get all groups to focus on common long range goals.

Examples were given relating specific productivity gains in various areas of United Air Lines to investment per employee and to the actual output per dollar of wages and benefits. It is important that productivity be related to wage and benefit policies, not just to employment or man-hours. One of this country's greatest challenges is to raise the economic understanding of engineers, workers, government officials, and the general public in these areas.

The recent productivity conference recognized the need for a national economic policy, but since the technological component is so large, there is a need for a national technology policy as well. The problems are too complex to be tackled by a NASA approach or a Manhattan-type project, but require working through the private enterprise system. The following actions were suggested toward developing a comprehensive national technological policy:

..... Establish long range goals in terms of rates of productivity and economic growth.

..... Consciously determine the kinds of technical effort needed and how it should be allocated.

..... Shift emphasis and the measurement of performance to a longer term basis.

..... Develop effective incentives for optimum level of private investment in R&D.

..... Provide for optimum public investment in R&D where market forces are not effective.

..... Eliminate institutional barriers against use of new technology, such as restrictive work rules and codes.

..... Seek to change governmental legal and regulatory policies which hinder the development and use of new technology.

..... Promote tax reform to encourage savings and investment for our capital formation needs.

..... Recognize replacement costs as the basis for depreciation charges.

..... Allocate productivity improvement effort to the ever-increasing services sector.

..... Seek a better understanding by labor, government, business and the public of their mutual stake in improved productivity.

..... Bring inflation under control by reducing federal deficit spending.

Summary of Remarks by Dr. Vincent P. Wright Manager, Management Development Program, Stone and Webster Engineering Corp.

America was the first nation to become a service economy. At present, close to *sixty* percent of our labor force is engaged in providing services, rather than producing products, and the so called service industries (trade, commerce, finance, professions, etc.) continue to grow. Although problems of adjustment are complex, the change has been the result of systematic forces rather than random happenings. In short, it is the result of heightened efficiency and the consequent affluence of the primary industries (agriculture, forestry, fishing) and the secondary industries (manufacturing, mining and construction).

This phenomenon, promoted by efficiency and affluence, moreover, has important consequences for the economy, for example:

1. more employment opportunities exist for young, old, and female workers,
2. greater opportunity for part-time work and urban self employment,
3. increased demand for workers with more formal education,
4. the possibilities for greater personalization of work,
5. a greater importance of small firms and non-profit organizations, and
6. the possibilities for greater stability in overall employment.

The societal movement toward tertiary employment, however, has to answer the question of how efficiently the service industries are using their manpower and other resources. For if the primary and secondary industries had not become so affluent and prosperous because of capital intensiveness, the American economy would not be able to spend so great a proportion of its income on services.

Productivity is difficult enough to measure in manufacturing, but in many services areas it is almost impossible. However, the importance of improving productivity in the service industries has been emphasized in recent years by the swift rise in service prices. Fortunately, the results of work begun by the National Bureau of Economic Research have surfaced recently on the measurement of productivity in the medical profession. The sixties found Medicare and Medicaid heightening the demand for services in the health-care industry, and in the process, exposed the fact that the nation's health resources were not always adequately distributed or utilized.

The National Bureau of Economic Research focused in on surgery and produced, with the aid of the medical profession, an ingenious answer, namely a unit of measurement called the "hernia equivalent". One hernia equivalent, or H. E., is defined as "the amount of surgical work equal to that involved in performing a unilateral adult inguinal herniorraphy". Thus in the medical profession some inroads have been made, for a consensus of general surgeons from a number of practice settings estimated that "10 H. E. per week would comprise a surgical workload sufficiently large to maintain operative skills and still leave adequate time for other professional and personal activities".

The movement toward greater and greater service employment also has important consequences for the engineering profession. At the moment, somewhere between forty and fifty percent of the profession are engaged in the service industries. Close to twenty percent, for example, are engaged in government and university work.

Contrary to the expressions of some reputable sources, education will play a greater role in the future than it has in the past. And management, our unique contribution to world economy, will require a more adequate grasp and a greater understanding of the fundamental principles underlying the basic functions of planning, organizing, staffing, directing, and controlling. At the moment, we are in an enviable position, for no other nation has democratized simultaneously educationally, economically and politically. This may not persist, however, for any extended period of time.

The engineering profession thus is rather uniquely equipped, in many respects, to make singular contributions to heightened efficiency in the tertiary industries, and to provide a firm base for the continuance of simultaneous democratization on the three essential fronts of education, economics, and politics.

Moreover, the fact that the engineering profession has a considerable proportion of its employment in the tertiary area means that the profession has greater stability in employment than is usually recognized. For it is the secondary industry group, not the tertiary area, which has the greatest amplitude in employment patterns, and it is moreover the secondary industries wherein depressions originate.

Summary of Remarks by Dr. K. Nagaraja Rao Center for Policy Alternatives, M.I.T.

My comments are directed at some policies needed to restore U.S. competitiveness in technology and the contribution U.S. engineering can make to national and international development.

The major changes in the international economic scene include increasing competitiveness on the part of other economies, a weakening of the technological postition of the U.S., and the breakdown of the international mone-

tary system. These changes, when juxtaposed with internal U.S. problems of inflation and capital flow caused by the higher fuel costs, take on a special urgency for national technological policy makers.

World GNP grew from 0.7 to 3.2 trillion dollars from 1950 to 1970, but the U.S. share declined from 39.3% to 30.2%. The shares of Japan and the European Community have increased steadily, while that of the Communist countries has remained about constant. (Table 1.) In economic growth and investment, several developed countries have been plowing back a higher share of GNP than the U.S. (Table 2.) Many of the same countries spend a smaller percentage on defense. The Japanese save more of their consumer income. The U.S. share of world motor vehicle production and raw steel is falling steadily. While the U.S. leads in the number of patents filed, the percentage of foreign patents is increasing and was 40% of the world total in 1970.

The U.S. share of world trade has declined since 1950. 1971 was the first year since 1893 in which the U.S. had a trade deficit. It has been argued that 600,000 to 750,000 jobs were lost between 1964 and 1971 as the trade balance shifted. However, most recent studies show that net job effects are relatively small, trade has an overall favorable effect on U.S. employment, and export-oriented jobs pay more than import-oriented ones. On the other hand, we need vigorous international trade to create jobs in the U.S. for about 100 million more people by 1980. The causes of the deteriorating trade picture are loss of U.S. technological superiority, weak price competitiveness, and inadequate domestic resources relative to the needs of the economy. In price competitiveness the U.S. still is in a favorable position, but foreign countries have the advantage of being able to devalue their currency readily. The U.S. has thus a great stake in the emerging international economic order.

The current world-wide recession has made unemployment a vexing social and economic problem also in Europe. Unemployment in the nine Common Market countries climbed from 2.7 million in April 1974 to 4.2 million this April. The industrialized countries have been hardest hit, and are no longer welcoming workers from poorer countries. Short-term measures have been taken to create jobs, and France and the Netherlands have restricted mass firings. Social security programs have been maintained despite large budget deficits. The health of our trading partners is of concern to the U.S. These countries have worked hard to close the technological gap and have largely stopped the "brain drain" to the U.S. Although the U.S. is experiencing severe unemployment, the country's engineering manpower picture remains bright. With approximately a million engineers and another 400,000 scientists, the U.S. enjoys a commanding leadership over other nations in this important resource.

We cannot expect to stabilize U.S. engineering employment completely in the face of conflicting political and economic policies. What is optimum for engineers may not be best for the entire productive sector, but we must find ways to bridge the valleys, while providing individuals freedom of choice in a technological society run on democratic principles. Sustained growth in engineering employment requires a growing economy. A first consideration is keeping our own house in order through strong and effective national technological policies consistent with a clean environment and social equity. Some major themes with significant implications for engineering manpower are:

1. New incentives for industry to increase productivity.
2. Government support for innovation in technology applicable to many firms and with large societal implications.
3. A new partnership between industry and education for continuing industrial training.
4. A global outlook by engineering societies, universities, and industries toward world-wide opportunities for U.S. technology.

TABLE 1

DISTRIBUTION OF WORLD GNP

	1950	1960	1970
United States	39.3%	33.9%	30.2%
European Community	11.1%	12.7%	14.8%
United Kingdom	5.0%	4.8%	3.6%
Japan	1.5%	2.9%	6.2%
Other Developed	10.5%	10.9%	9.7%
Less Developed	9.1%	6.5%	10.0%
Communist:			
Other	6.0%	5.3%	5.0%
China	4.0%	4.5%	4.0%
USSR	13.5%	15.5%	18.5%
Total, Trillion US $ (current prices)	$0.7	$1.5	$3.2

TABLE 2

GROSS INVESTMENT* AS A SHARE OF GNP
(1968-70 Annual Average)

United States	18%
United Kingdom	19%
Italy	21%
Belgium	23%
Canada	23%
Netherlands	26%
France	27%
West Germany	27%
Japan	39%

*Investment includes private and government

5. Aggressive promotion of U.S. technology through exports, with emphasis on civilian technology in areas where we can do best.
6. Organization for screening world technological developments for application in the U.S.
7. A strongly pro-technology posture by engineering societies with the realization that the revolution of rising expectations is sweeping the world and that U.S. engineering has an important role to play in it.

Summary of Remarks by Ronald E. Kutscher Chief, Division of Economic Growth, Bureau of Labor Statistics, U.S. Department of Labor

A brief examination of post-World War II recessions of the U.S. economy, hopefully, may provide some useful insights as to the near term future of the economy. Also, to what extent this may influence employment of engineers is examined. The following data show the performance of the economy during and after each of the previous recessions.

	1953-54	1957-58	1960-61	1969-70	1974-75
1. Gross National Product (percent change in constant 1958 dollars)					
Recession (percent change)	-3.5	-3.5	-0.7	-1.4	-8*
First year after recession end	+8.1	+7.0	+7.4	+5.4	
Second year after	+2.3	+4.6	+4.1	+7.1	
2. Change in unemployment rate (measured as changes in percentage points)					
Recession	+3.4	+3.1	+1.9	+2.4	+3.6*
First year after recession end	-1.5	-2.2	-1.5	-0.0	
Second year after	+0.1	0.0	+0.2	-0.5	
3. Employment (percent change in employed persons)					
Recession	-3.1	-2.1	-1.0	0.0	-2.5*
First year after recession end	+4.7	+3.2	+1.4	0.0	
Second year after	+1.9	+2.0	+1.5	+2.4	
4. Disposable personal income (in constant 1958 dollars)					
Recession	-0.7	-0.8	+0.2	+3.1	-5.2*
First year after recession end	+7.7	+5.0	+6.0	+4.4	
5. Employment of engineers (percent change)					
Recession	NA	-3.9	+6.8	-5.4	-4.7*
First year after recession end	NA	-4.0	+0.4	-1.2	
Second year after	NA	-0.1	-0.1	+2.3	

*Through first quarter 1975.

A few comments can be made about these data. As measured by GNP decline, this is the most serious of the postwar recessions. In the more severe recessions (1953-54 and 1957-58) the year following the recession end is marked by very strong growth in GNP and employment, while the second year is characterized by more nearly normal growth for the economy. Not only is the current recession more severe as measured by GNP, but it is the only postwar recession characterized by a marked downturn in real income. The downturn in real income reflects not only lower GNP but rapid increase in prices and is an important element providing uncertainty as to the strength of this recovery. Without this uncertainty, the normal expectation would be for at least one year of vigorous growth in GNP and employment. In the past, employment of engineers has not shown a close parallel with changes in the business cycle—at least for those years for which data are available. However, during this recession employment of engineers has shown a close parallel with business cycle changes. If so, employment of engineers should recover during the next year at least to the extent the rest of the economy recovers.

Summary of Remarks by Samuel B. Batdorf Principal Staff Scientist, The Aerospace Corporation

Developments affecting U.S. engineering and technology in recent years are disturbing. We are losing our international leadership in one field after another to other countries — even in steel and automobile production. Internal problems include decaying cities, obsolete rail transport, a growing energy crisis, engineering unemployment, and an oversupply of PhDs. Patent office figures suggest that Americans are becoming less inventive.

There are those who believe the problem is lack of a national science policy. Others look to better manpower planning for the cure. Some believe we need incentives to stimulate R&D or capital investment. Others blame the adversary relationship between capital and labor, or business and government. Universities are criticized for educating their best students to turn out learned papers instead of better commercial products. Because the problem spills over into so many areas, our approach to solving it is fragmented. If it stays that way we can expect to lose our technical and industrial leadership.

Perhaps one reason for our lack of progress is that engineers have traditionally confined their attention to narrow fields of expertise. It might help to have a blue-ribbon committee of technical leaders formulate a get-well program, which should include specific recommendations for action. These recommendations would constitute social technology and would therefore warrant a technology assessment to ascertain secondary or tertiary effects and to review alternatives.

It should be recognized that the better utilization of engineers will only come about if it is generally accepted as necessary for the benefit of the nation as a whole. Recommendations from engineers in areas related to

engineering employment are likely to be greeted with skepticism. To be credible, the assessment group should include top talent from all appropriate fields, and include but not be dominated by engineers and scientists. Properly done, such an assessment should focus national attention on both the problems and the solutions, and might be the turning point in our downward slide.

Summary of Remarks by Dr. Fred Landis Dean, College of Engineering and Applied Science, University of Wisconsin at Milwaukee

The growth and change in engineering manpower can be simulated by a computer model in which all important supply and demand factors are represented. Initial results permit a number of conclusions having public policy implications. Small fluctuations in GNP can be accommodated without major manpower disturbances as long as R&D is maintained at a proportionately high level. However, once a major fluctuation cycle is initiated, especially if R&D spending is also reduced, the disturbance feeds on itself and recovery tends to be much slower than the downturn. The magnitude of the disturbance is more important than its duration. The only effective corrective measure is the direct application of funds to the labor market. Early recognition of downturns and the rapid application of countermeasures are a prime requirement if unemployment is to be checked. Retraining programs are usually counter-productive because of characteristics of the timing cycles involved.

Although some of the data and factors used in the model had to be estimated, they can easily be adjusted when better information becomes available. The model can be used to explore a wide range of assumptions about the future and is a useful tool for manpower and policy planning rather than a device for predicting the future.

Note: A full description of the model has been published under the title "The Effect of National Spending Practices on Engineering Employment". Readers are urged to contact Dr. Landis for further information about this report and the model itself.

Summary of Remarks by Dr. Russell C. Drew Director, Science and Technology Policy Office, National Science Foundation

Note: The full text of Dr. Drew's address is included in Part III of these Proceedings. In view of the importance of his remarks, readers are urged to refer to the text for a more detailed exposition of the points summarized below.

A serious deficiency in federal organization is that science and engineering manpower has no single home, which means that it essentially has no home. Despite this, the government has done a great deal in collecting and analyzing manpower statistics, improving the quality of the educational system, setting standards, and operating employment and unemployment programs. Indirectly it has created strong demands for engineers through large scale development programs, whose abrupt effects on manpower are not adequately appreciated by some federal agencies.

The government has not attempted to limit the number of people entering a field, to set salaries and benefits, to engage in a "technological WPA", or to set professional standards. These are generally seen as areas in which the federal government should not play a role. Overall, the government has not been very effective in dealing with the problems of oversupply, underemployment, or unemployment.

For the last two years the Director of NSF has also been serving as the President's Science Adviser. Now the President has proposed a new advisory structure for science and technology policy, with the inclusion of the word "technology" intended to imply a stronger focus on technological matters. NSF has also been reorganized to consolidate science and technology policy-related activities into a new Directorate of Scientific, Technological and International Affairs. It is hoped that the new directorate will serve as the focal point for science and technology manpower questions.

Hurdles to be overcome in establishing new manpower programs include administrative inertia, review by the Office of Management and Budget, and the Congress. There is a strong feeling in some quarters that engineers and scientists do not deserve special consideration. Therefore, the engineering community must recognize these hurdles and build a constituency and communication channels to the political structure if it wishes to make its voice effective.

Major trends developing in Washington are that manpower training will be supported selectively in disciplines that represent scarcities, the federal government will play a stronger role in supporting the colleges, curriculum development programs will be more closely scrutinized, productivity is becoming a major concern in policy analysis, level funding of R&D will be emphasized, the federal regulatory role will be under close scrutiny, and better communication is in prospect between top levels in the Administration and leaders of the scientific and technological community.

Summary of Panel on Women and Minorities in Engineering Moderator — Jean P. Moore, Board on Engineering Manpower and Education Policy, National Research Council

Melvin W. Thompson, Executive Director, Committee on Minorities in Engineering, National Research Council

The National Research Council's Committee on Minorities in Engineering was initiated by the National Academy of Engineering in 1973. The purposes of the Committee on Minorities in Engineering are to identify

resources, coordinate information, provide a national focus for minority engineering activities, support studies and reports, and keep track of graduation and enrollment trends through cooperation with the Engineering Manpower Commission. Various subcommittees and task forces are active. A National Scholarship Fund for Minority Engineering Students has been created and will distribute grants this fall. A variety of techniques and strategies are being employed to address the educational problems and barriers facing Blacks, Mexican Americans, Puerto Ricans and Native Americans inhibiting them from representational participation in engineering. The organization is basically voluntary, with a small Committee staff. The Committee invites all to join them in addressing this national priority to increase the number of minority engineers.

Carolyn F. Phillips, President, Society of Women Engineers

Until recently society has been deprived of the talents of 50% of the people who could contribute to the solution of our technological problems. We can't afford to waste the brainpower of women, because only a small part of the population is truly creative and innovative. There are two basic issues as far as women in engineering are concerned. First is their under-representation in the profession, which is still less than two percent but growing. Second is the infrequency with which women advance to higher levels in industry, government, or education. Education, economic forces, family and social factors all influence women's perception of career opportunity. Sex discrimination was once a philosophical and moral issue; now it is a legal issue as well. SWE is now in its 25th year. Its membership is growing rapidly and is now over 3000, of which two-thirds are students. Its objectives are to inform people of the opportunities for women in engineering, to assist women engineers in returning to active work, and to encourage high attainment in the profession. Student groups are particularly active in spreading the word among young women, and are very effective at the local level. The society is expanding its efforts to reach girls from the lower school grades upward. It is giving students a more active voice in management of the society, and is opening membership to men. SWE has established a Career Information Center for job information on its members. Its scholarship and awards program is growing, and industry is providing increasing support. The main concerns now are to avoid reverse discrimination such as excessively high starting salaries. Women engineers do not want to be stereotyped or offered token jobs. They want to be fully utilized, to have equal opportunity for advancement based on merit and performance. Women want to be hired for their abilities, not because employers are forced to by laws or pressure groups. The number of women engineers graduating from school was about 745 last year. This is nowhere near enough to meet employment needs. Discrimination still exists in subtle and changing forms, but it is obvious that women will continue to play a more important role in the engineering profession in coming years.

David R. Reyes-Guerra, Executive Director, Engineers' Council for Professional Development

ECPD is responsible for centralized career guidance activities on behalf of its member societies. This activity is carried out by the ECPD Guidance Committee and two other organizations that are housed with but separate from ECPD – the Minority Engineering Education Effort (ME³) and the Junior Engineering Technical Society (JETS). A particularly relevant activity being carried out now is the Minority Introduction to Engineering (MITE) program. This a 2-week residency experience on a college campus for minority high school students between their junior and senior years, during which they learn what engineering college is like. This year there are nearly 1200 students in the program and next year it is expected to reach 1800 or 2000. The programs are supported by industry and the schools, and are one of the most visible ways available for increasing minority participation in engineering.

George D. White, Regional Equal Employment Opportunity Representative, U.S. Civil Service Commission

The activities of the Civil Service in the area of equal employment opportunity are all within the context of the merit system which requires that all appointments and promotions be made from among the top three candidates on a register of qualified applicants. With respect to engineers and related professionals the focus is on outreach. The Civil Service sends people to recruit at schools where minority candidates are available. When the equal opportunity program was established in 1968, a study was conducted which showed a significant number of minority women in the federal service, but at lower job levels. Consequently the system has been promoting upward mobility. In 1972 all federal agencies were required to prepare affirmative action plans for review and approval by the Civil Service Commission. Plans must cover the allocation of resources, upward mobility, and the qualifications of individuals administering the program. Statistics are now being published annually on minorities, but not yet for women. The latest figures show that 64% of the increase in non-postal federal employees during the 1973-74 fiscal year was composed of minorities. The actual net increase was 19,982 persons, of whom 12,665 were minorities. The most significant increase was in the white-collar schedule. The high proportion of minorities hired has resulted in complaints of reverse discrimination being filed by white male applicants. Overall, however, women and minorities are still significantly below the desired levels of employment in the federal establishment. The recruitment of engineers depends on local needs, which are not strong in the Boston area at this time. However, because minority engineers are so scarce, they appear to have no trouble in being selected whenever they appear on registers. The situation is not so clear with respect to women, and more

effort needs to be devoted to improving the awareness and sensitivity of supervisors and managers within the federal establishment.

Summary of Remarks by Robert G. Ainsworth National Commission for Manpower Policy

The National Commission for Manpower Policy was created under the Comprehensive Employment and Training Act of 1973. The Commission is responsible for examining national manpower issues and making recommendations to Congress and the President. Specific objectives are to identify manpower goals and needs of the nation, assess national employment and training programs, determine how the various manpower and human resources programs can be more effectively coordinated, and make studies of the manpower impact of energy shortages.

The Commission is an independent agency. Its members consist of the heads of 6 federal agencies and 11 public members appointed by the President. Public members are broadly representative of industry, labor, commerce, education, state officials, and persons served by the manpower programs. The Commission's reports to Congress are made directly without clearance within the executive branch. It is also authorized to make recommendations to the President and heads of federal agencies as it deems appropriate.

The Commission has developed its work program against a backdrop of rising unemployment. One aspect is focused on the long range development of a national manpower policy framework, the other on shorter range studies of a more immediate nature which represent elements of such a policy. The U.S. presently does not have a national manpower policy. It does have a number of manpower training and related human resource programs including the public service employment program and unemployment insurance system. In the current state of the economy these programs are inadequate. Even when the economy has recovered, many structural problems will still be with us – high unemployment in localized areas and among disadvantaged groups, and continued unemployment and under-employment for some engineers. New problems are likely to emerge after the recession. Unemployment may stay at unacceptably high levels, and the automobile industry may not return to former production levels.

The Commission is exploring ways to develop a better interface between manpower policy and economic policy. Decisions by agencies responsible for the nation's economic planning frequently include little or no attention to manpower implications. This will be addressed in the Commission's recommendations. It is also informing itself about the experience of European countries that follow what is called an active manpower policy, and has invited the nation's leading experts to provide guidance on how to achieve full employment.

The current recession has confirmed the need for a comprehensive set of manpower policies closely integrated with economic and other policies. It is clear to the Commission that there are no panaceas or simple solutions, but the problem is one of our major national priorities.

Summary of Remarks by Martin M. Frankel National Center for Education Statistics, Department of H-E-W

The National Center for Education Statistics compiles annual data on engineering degrees by level of degree and subfield for each institution, with state and national totals. Enrollment statistics are available for advanced degree students. The 1975 report will also include upper division undergraduates by field. Projections of future degrees are made for the next 10 years based on past trends and data on freshman enrollments as reported by EMC. The projections for bachelor's degrees are based on the assumption that the percentage of graduates out of freshman enrollments four years earlier remains constant. Recent information from EMC indicates that attrition rates are not as high as they used to be, that more women are entering engineering, and that more students are transferring into engineering from other programs.

Projections are made for use by the Department of Labor in the Occupational Outlook Handbook. The breakdown by subfield assumes that the averages for 1969-1973 will remain constant.

NCES is still behind schedule in publishing data from previous years but has increased the number of publications issued this year and has also established a time sharing computer terminal system for direct access by persons needing educational data.

Summary of Remarks by Norman Seltzer Study Director, Manpower Utilization Studies Group, National Science Foundation

Following the 1970 census, NSF made a follow-up survey of about 100,000 people who had been classified as engineers, scientists, technicians, or related titles. The returns were screened according to sets of criteria based on the respondents' answers to questions about education, employment, and professional identity. These criteria were established in consultation with the professional groups concerned. The analysis showed that 43% of the persons initially categorized as engineers and 57% of those classified as scientists did not actually possess professional qualifications. In the case of engineers, the census count of 1,243,000 was reduced to 678,000 by the screening, but 308,000 qualified engineers were found under other occupational titles, making a total redefined engineering population of 986,000. Because of the major shift of people from their original census classifications,

the characteristics of the engineering population in many instances are substantially different from those derived from unscreened census data.

Detailed results of the postcensal study have now been published in "The 1972 Scientist and Engineer Population Redefined, Volume I, NSF 75-313," which is available from the U.S. Government Printing Office, Washington, D.C. 20402 for $3.70 per copy. Two summary reports, "Selected Characteristics of Five Engineering and Scientific Occupational Groups," NSF 73-306, and "The 1972 Scientist and Engineer Population Redefined," NSF 75-305, are available gratis (single copies only) from NSF, Washington, D.C. 20550. Readers are urged to refer to these publications for specific information on the subject.

Summary of Remarks by Daniel E. Hecker Division of Manpower and Occupational Outlook, Bureau of Labor Statistics, USDL

Note: the full text of Mr. Hecker's paper is reproduced in Part III of these Proceedings. Readers are referred to that paper for a detailed explanation of the process summarized here.

The Bureau of Labor Statistics publishes the Occupational Outlook Handbook to give students an indication of the prospects of finding a job in a particular occupation. It also publishes projections to give educational planners an indication of how many people are going to have to be trained in each field.

The Bureau projects engineering requirements for 1985 at about 1.5 million, up from 1.1 million in 1974. This is a 36 percent increase, a somewhat greater increase than expected for the economy as a whole. These projections indicate an annual average of about 76,000 new entrants will be needed through 1985. About 36,000 openings each year between 1974-1985 are expected from growth, and about 40,000 openings from deaths, retirements, and transfers out of the occupation.

In terms of supply, an annual average of 38,000 new entrants with B.S. degrees in engineering is expected from U.S. schools. In addition, if entrants from other sources fill engineering openings in the same proportion as they did in the 1960's, BLS expects about 7,000 per year from other college degree programs, a similar number of immigrants, and 23,000 from upgraded technicians and transfers from other occupations.

Total supply is calculated to be 75,000 per year, roughly equal to projected requirements of 76,000 per year.

Summary of Remarks by Dr. Peter Chiarulli Dean of Armour College of Engineering, Illinois Institute of Technology

Before attempting to develop national policy recommendations, it is desirable to look at continuing education in a broad context and note what major problems exist. Two basic assumptions underlie this analysis. First, the future welfare of the nation depends critically on the development of a large body of engineering workers across the whole spectrum of employment, who are knowledgeable of the latest technology or participating in the development of new technology. Second, a major motivating drive for engineers is success in challenging work assignments. Additionally, however, this drive is not sufficiently strong to induce engineers to consistently put in a work week greater than the standard, nominal 40 hours per week.

In terms of how engineers are typically used, I would like to consider two approaches. Scenario A involves hiring young engineers at relatively high salaries, using them intensively on assignments within their capability, and dropping them at age 40 or 45. Scenario B is for industry to use young engineers carefully, program them through increasingly significant responsibilities, support their continuing development with opportunities for challenging advanced assignments, and keep them as long as their capacity is not exceeded. Depending on their inclinations and abilities, they are compensated equally for either technical or managerial excellence.

In the United States, the current profit and tax system encourages Scenario A, but this is contrary to the original basic assumptions. Therefore national policy should be changed to make it profitable for employers to follow Scenario B.

Presuming Scenario B, the emphasis on development of the engineer must include significant elements of Continuing Professional Development. This is best effected on the job, not necessarily through formal degree programs. As such it would require special programs, materials, and procedures to facilitate learning. In order to prepare engineering students for such a process, basic engineering education must be changed. Programs for learning specialties should be operated by companies and engineering societies, independent of and in cooperation with engineering schools. The societies should also certify engineers in their specialties and keep records of in-service training for their members.

Summary of Remarks by Israel Katz Director of Advanced Engineering Center for Continuing Education Northeastern University Boston, Massachusetts

Note: A detailed set of supplementary notes for Prof. Katz's talk is reproduced in Part III of these Proceedings. Readers are referred to these notes for a more comprehensive treatment of the points mentioned in this summary.

Continuing education can be likened to a temple whose foundation consists of knowledge resources of all kinds and whose roof, representative of competence, is held up by five pillars. The central pillar is *learning on the job*, which is the key to keeping engineers current, com-

petent and competitive. Why? Because engineers spend most of their alert time on their jobs and those jobs should have substantial intellectual content. An engineer's work should be a continuous learning experience, with supplementation from educational institutions or other agencies only for that which cannot be acquired or provided on the job.

The next essential pillar represents an engineer's learning readiness, which involves job satisfaction and challenge. It is almost impossible for unemployed engineers to participate in this kind of education because they are too preoccupied with more basic needs.

Informational content, represented by the third pillar, should be of the sort that supplements what the individual is learning on the job. The fourth pillar represents some responsive agency to conduct the required educational programs. This agency could be a university, but few universities are truly responsive to this need, or the response is poor because the fifth pillar—representative of an enlightened sponsor—is missing. Most engineers will not pay for their own continuing education because they feel that their employers should carry the expense if they put in their time. In fact, it is easier to get employers to pay a higher price for a course or seminar than to get individuals to pay as little as $10.

Large industrial corporations can run in-house continuing education programs because they can pull together enough qualified people to make courses interesting. Smaller organizations look to a nearby university for programs that draw upon several local sources of people in search of education.

Some engineers resist continuing education given by universities because they think they learn all they need to know on the job. Actually, few professionals can learn 100% of what they need to know to keep abreast of developments in their fields just by doing their jobs. Some engineers learn nothing on their jobs and others even forget more than they are learning. Because of rapidly changing science and technology, engineers who learn less than 100% of what they need to know to keep doing what they are doing, are falling behind and therefore need supplementary education in subject matter that is too difficult, peripheral, or time consuming for busy professionals to acquire alone or on the job. One study concluded that most active professionals gain 85% of their new knowledge from practice, and only 15% from academia.

Two things that keep able and willing universities from being more responsive to engineers' needs for continuing education are the unanticipated effort required to develop a program and its related costs. Moreover, continuing education for professionals is not really a money-making activity like undergraduate education for adults. Consequently, most schools are unwilling or unable to make the investment in the educational research and development required to mount an effective program. As a result, continuing education for professionals in the future may be taken over by industry or the professions running their own schools. Unfortunately, such a takeover, which already is in progress, will not only divert substantial funds from industry into its own programs, rather than going as gifts to academia, but also shut off the potential injection of new knowledge generated in professional practice into academia curricula.

Summary of Remarks
by Dr. Warren C. Stoker
President, Rensselaer Hartford Graduate Center

Note: The full text of Dr. Stoker's paper is included in Part III of these Proceedings. Readers should refer there for a more comprehensive exposition of the points summarized here.

The Rensselaer Hartford Graduate Center is especially devoted to the concept of keeping engineers at a proper level of competence to meet changing needs. A few years ago the Center started to re-examine its purposes and plan new programs in response to the changes that are taking place. As a result of this study it has been concluded that the concept of continuing education is foreign to most employers, that advanced degree programs have not met corporate needs, and that educators must develop programs that are more responsive. Traditional industry/academia meetings have not been very successful in determining continuing education needs, and faculty-developed concepts are often unrealistic. In order to bridge the communication gap, closer working relationships must be established between academia and industry. Educators must concern themselves with human aspects of the learning process, not just the skills content of the courses.

Summary of Remarks
by Russell R. O'Neill
Dean, School of Engineering
& Applied Science,
University of California at Los Angeles

Note: The full text of Dr. O'Neill's paper is included in Part III of these Proceedings. Readers are referred to that paper for a fuller explanation of the points summarized here.

The majority of new engineers enter the profession of engineering after completing a university degree program. However, continuing education determines how effectively and for how long the new engineer will practice. Although continuing education has a major impact on engineering manpower, it has neither the data base nor monitoring which is available for degree programs. In its broadest context continuing education includes on-the-job experience, technical literature, and professional relationships with other engineers. However, more attention must be given to planning, operating, and evaluating formal continuing education programs.

There must be a national policy which will provide incentives. Engineering manpower is one of our nation's most important resources. Fortunately it is renewable but even so it must be properly used and conserved. In the

short run it may appear to be cheaper to hire new engineers than to retrain those already in the work force, but it cannot be cheaper in the long run when the subsidy for education is counted.

Educational institutions spend hours of faculty time planning curricula and courses to prepare students for entrance into the engineering profession. On the other hand continuing education programs are so dominated by a single input – the number of students who sign up for a particular course – that there is no opportunity for real planning. Today's engineering graduates have different expectations, values, and attitudes toward work. Thus the total workforce is very diverse and the planning of continuing education for this large, heterogeneous group is difficult, requiring explicitly stated goals and objectives. Operating a continuing education program is also a problem due to tight budgets, low priority, and the effects of external factors such as general economic conditions. Perhaps the most difficult area is evaluating the program's contribution to the subsequent output of the participant. We have no way of demonstrating the importance of continuing education to success on the job. This conference is urged to ask for a national policy calling for the continuing education of engineers.

Summary of Remarks by Donald B. Miller Program Manager for Human Resources, General Products Division of IBM

An objective of this conference should be to propose a national policy statement as an alternative to the continuing education portion of Senate Bill S-32. It is too simplistic to think of continuing education as the only key to continued growth and vitality of engineers. Recognizing the importance of engineers as managers of the frontier of progress and catalysts for creating a better life, it should be national policy to provide challenging and meaningful work in a growth-oriented learning enviroment. We need to find better ways of looking at the role of engineers and extending their productivity well beyond the age of 35 where it now is reported to start dropping off. The drop-off is believed to be more a result of environment than biology. One of the reasons young people are not entering engineering study and careers is their belief that engineers are burned out by age 35 or 40. When managers expect people to slow down and treat them accordingly, they usually do slow down. We need new expectations and the environment to support them.

We need to establish a center to study the careers, growth and motivation of engineers. The center is needed because this is a matter of different and changing priorities for different groups. We need to understand more about learning, and also unlearning to get rid of the consequences of previous learning that block adaptation and change. We need to study management and organization theories, and career management. People today are going through a series of careers, each with its own base of learning and doing. Portions of the old career get carried on to the next one, but each career also needs some new input. Thus, managing career change is a needed skill to enhance engineering productivity.

Different groups tend to see the problem from a narrow and incomplete perspective. To education the problem is seen as rapid change in the knowledge base, and the answer is more and continued education along existing lines. Industry sees the problem as obsolescence and declining motivation, and the answer consists of improved motivational schemes, technological updating, and weeding out the nonproductive. The individual thinks the problem lies in not knowing what skills will be needed tomorrow, and how to get there. This is complicated by our lack of ability to predict future skill and manpower needs. Government views the problem simplistically as fluctuations in supply and demand and lack of application of engineering capability to meet national needs. Its answer is better manpower planning, continuing education, and a more responsive educational system.

In order to bring these divergent approaches together the following actions are proposed:

Industry:

- work for improved congruence between company goals and individuals' goals.
- Encourage employee self-analysis and statement of personal goals.
- Improve definition of and employee participation in company goal setting.
- Set up learning and growth as objectives of work. Improve opportunities for change and facilities for study.
- Work with education to provide new learner-centered growth programs.
- Open the avenues for use of education and growth activities as bridges to multiple careers and jobs.

Education:

- Change from classical hierarchical degree thinking to personally-oriented growth programs.
- Expand concept of continued education for engineers from more technology to education of the whole person.
- Move toward life-long educational service and joint activities with others as well as credit for non-course activity.
- Develop improved career/education counseling capability.
- Increase understanding of learner motivations throughout life and apply to program design and packaging.

Individual:

- Accept growth and vitality as objectives for life.
- Increase personal responsibility for success in life and work.
- Analyze strengths, weaknesses and needs in order to become better individual negotiators over work content, quality, and character.
- Work with employers toward understanding the

need for assistance in goal changes and career changes.

- Unlearn the cultural pattern that decline is inevitable and giving up is O.K. as one grows older.

Government:

- Implement the proposed policy and demonstrate leadership in government-managed and sponsored research, development and engineering activities.

Summary of Remarks by Dr. M. E. Van Valkenburg University of Illinois

Note: These remarks were based on a paper originally prepared by M. E. Van Valkenburg and Donald O. Pederson

The need for a 2-year forecast – an "early warning" system – to tell those preparing to enter industry the "outlook" for two years in the future is presented. It is intended that this be an advisory system from industry to the student indicating areas in which jobs will likely be available, an alternative to our present "free enterprise" or "laissez-faire" system.

From the point of view of students in universities, the need stems from such factors as these:

(1) Advice to students is generally not available or wrong. Placement officers have no reliable data, and professors seldom have a broad viewpoint, but favor their own specialty.

(2) The first job syndrome: industry seeks graduates with specific skills, more specialized the higher the degree. They are seldom interested in a "truly exceptional" graduate in the wrong field.

(3) In terms of specialized areas within a field, in some areas the universities cannot supply enough students, while in other areas the students cannot get jobs.

The paper points out the need to disaggregate. Hiring is done by subdisciplines, not the disciplines themselves. A solid-state engineer is not interchangeable with a power engineer, for example, even though both are electrical engineers. Specifically, the need for establishing a relative demand index is presented. The index numbers might be gathered from representatives of management. Their responses would be combined, the scale adjusted, and the index number found. The same task would be undertaken to compare the different branches of engineering. In addition, fungibility indices for the various subdisciplines should be determined to warn students of areas of over-specialization that might inpair future professional advancement.

Summary of Remarks by Dr. Dean Gillette Executive Director, Systems Research Division, Bell Laboratories

Note: The complete text of Dr. Gillette's paper is reproduced in Part III of these proceedings. Readers are urged to refer to it for a fuller treatment of the points summarized below.

From an industrial viewpoint we need to start with factual data. Even so, there is much variation in interpreting what the facts mean, especially when we try to project historical trends into the future. Examples from the telephone industry illustrate the difficulty in trying to project the need for engineers in the year 2000 when the possibility of major technological changes is considered.

Some projections suggest that the demand for engineers depends on the GNP. The reverse is equally true, in that the employment of scientists and engineers in industrial growth and R&D is what stimulates the economy and raises the GNP. This is supported by figures that show a high degree of correlation between industrial growth and R&D intensiveness. The R&D intensive industries also lead in sales of new design products and in productivity.

Our advice should be to stimulate the employment of scientists and engineers in areas where we are technically lagging. Industry has repeatedly complained about pressures from government that discourage economic growth, productivity, and invention. Most of the technological innovation in the latter part of this century came from very large corporate enterprises. Major innovations in the future will require having scientific and technological communities that are big enough to do the job, but the government is trying to restrict such growth.

Bell Laboratories supports a major in-house continuing education program for its technical employees, which attracts engineers of all ages to participate. This kind of program should be encouraged.

Summary Remarks
by Dr. Cornelius Wandmacher
University of Cincinnati

First and foremost there should be recorded a commendation to all who participated in this Conference for the wisdom, the perceptiveness, the spirit of intellectual stimulation, the free and open exchange of vital information, and the friendly repartee which has been the tone of all sessions. It is thus with due acknowledgment of indebtedness to many presenters and discussors that the following observations and recommendations are offered:

1. To provide a spring-board for follow-up action, it is recommended that a set of Conference Notes be produced immediately by the Engineering Manpower Commission. These "Notes" preferably should include informal statements from discussions as well as formal presentations, as may be available. The "Notes" should not be merely an historical document but more so a mechanism for action, with a target date for publication as of October 1.

2. Since a report at this Conference is to be made to the Association for Cooperation in Engineering (ACE), which includes EJC, ECPD, ASEE, NSPE, and twenty-five (25) other engineering societies, at the annual Joint Societies Forum, it is recommended that all engineering societies be urged to act in concert with EMC and that EMC strive to involve all of the engineering societies more fully in all of its activities.

3. "Where Do We Want To Stand?" was the vital challenge presented appropriately and forcefully in the keynote address. In respect to manpower, this is still a critical issue that must be decided by Engineering as a professional group.

4. Also in the keynote address it was made clear that there exists a diversity of engineering opportunity ranging from high technology through low technology areas on one hand to high risk and low risk areas on the other. Productivity in *all* of these areas can be enhanced by the imaginative utilization of engineering competencies.

5. That manpower modeling and simulation is feasible and enlightening was well demonstrated. It is recommended that the pursuit of mathematical modeling of manpower demand and supply interlocks be further explored, developed and promoted.

6. Conferees appeared unanimous in the view that engineering manpower is a vital national resource which must be consistently developed and well-utilized for the health of the nation's economy.

7. Manpower development, it was observed, is the management of a total organic system in a dynamic environment based on the following people-oriented elements:

(a) selection, (b) motivation, (c) education;
(d) providing the opportunity to perform (the real pay-off);
(e) evaluation of performance;
(f) providing a reward system;
(g) re-cycling. . .(the most critical of all). . .periodically going back to selecting people for advancement into new responsibilities, re-motivating, re-educating, etc.

8. Manpower development is obviously much more than the counting of heads, but numbers can be significantly related to qualitative aspects. Greater emphasis in manpower statistics might well be put on engineering "functions" rather than on fields.

9. With respect to the image of Engineering it may be timely to proclaim that, indeed, the vast majority of engineers do know where they want to go, are going there, and are making major contributions to the nation's productivity.

10. Engineering now, as it always has, presents a challenging career opportunity as a "manager" of the frontier of human progress, or as a "catalyst" for developing productive work for others.

11. There are several erroneous and unfortunately popular "notions" which must be dispelled. These stem from the much overworked phrases of jargon purporting that: "an engineer is burned out at 35"; or, "the half-life of an engineer is seven years"; or "the product of today is obsolete tomorrow." Perhaps these well-meaning observations now have been dwelt-upon and re-recited to an extent that has been more detrimental than rewarding for the profession.

12. Engineers can point with pride to the developing opportunities for a normal career migration. Starting in design and going on into management is not leaving engineering but rather such advancement is building upon sound experience as a design engineer in a logical, healthy, productive career sequence. In such matters there is always an opportunity for the engineer and the employer to work for greater congruence between individual and company goals.

13. Strong feelings were expressed that engineering education should move to a greater extent away from classical, hierarchical, degree curricula patterns toward more offerings of personally designed growth programs with sequential milestones.

14. Individual engineers must accept growth and vitality for life as a part of professional responsibility.

15. Government should set leadership examples in the sponsorship of career development programs for engineers both in the direct employ of government agencies and also for those employed by government contractors.

16. The concept of throw-away manpower. . .as with cans and bottles. . . .must be dispelled.

17. Government policies impacting on major engineering projects should appropriately include manpower development incentive programs and also manpower conservation provisions.

18. A new major national study should be made of the present utilization of engineering competencies.

19. The engineering profession should anticipate that there are many positions now held by engineers of an earlier vintage that in the future may not be filled by persons with an engineering education, but at the same

time recognize that there are many new positions created by the advancing economy which can be filled optimally by engineers only.

20. Much more attention needs to be given to analysis of functional needs and better definitions of the types of individuals needed. The current efforts of EMC in the study of needs for engineering technicians and engineering technologists should be more widely supported.

21. In engineering as in any profession, the prime objective must be the building of individual competencies. The best motivation is challenging work – the best learning is learning on the job – learning by doing. Sponsorship, in one way or another is needed to make the success of building individual competence. This is not necessarily continuing education in itself, but more so the broad scope of continuing professional development (CPD), of which continuing education may be a central part.

22. CPD embraces career planning, attitudinal development, anticipation of job change, recognition of the need for mobility, growth, and adjustment.

23. The current Employment Guidelines, recently endorsed by most of the major engineering societies, have been generally well received but may need strengthening on the side of the responsibilities of the individual engineer.

24. In respect to traditional tuition remission plans for education, it may be expected that these will be under close scrutiny as to their value in meeting the real needs of the sponsor as well as the demonstrated competencies of the individual.

25. There seems to be little likelihood for the development of any single standard for CPD although there is, indeed, growing recognition for the c.e.u. as the "continuing education unit".

26. Whenever it can be appropriately arranged, some form of over-all recognition such as "certification" by an approved national professional body would seem desirable.

27. Continuing education henceforth will be "a way of life" for the professional engineer. An increasing number of proprietary and society groups can be expected to provide such opportunities in the future, especially where educational institutions do not otherwise fulfill the needs of the business and industry.

28. In regard to formal education, it is suggested that the concepts of the core curriculum, or the basic curriculum, at the baccalaureate level be "revisited", especially from the point of view of improving the fungibility (interchangeability) of bachelor's degree holders.

29. It seems timely to recommend that ASEE consider a new appraisal of engineering education, a study of how students can best be prepared for multi-career prospects and for various ways of facing up to the multi-faceted aspects of the demand for engineers in industry, business, government, and private practice.

30. Educators should become more fully a part of the system they serve. It is specifically recommended that both the involvement of faculty members in engineering practice and the involvement of practicing engineers in the educational function be expanded.

31. The selection of practicing engineers to participate in engineering education should be based on their ability to intellectualize on their experiences in practice.

32. The two-way inter-change, and consequent two-way stimulation, can be effective both in formal and in continuing education. Especially in continuing education there is much that an instructor may learn from students under his tutelage.

33. Additional recognition and broader support might well be given to the program of Faculty Residencies in Engineering Practice, now being conducted by ASEE.

34. Impressive advances have been made by NAE, ECPD, and ASEE in advancing toward the objectives of "Minorities in Engineering – A Blueprint for Action", a comprehensive report and manpower plan sponsored by the Sloan Foundation.

35. Encouraging progress is affirmed by the Society of Women Engineers toward involving women in the full range of engineering responsibilities, including the teaching of engineering.

36. It is recommended that SWE consider a future conference on career development of women engineers including work motivation, upward mobility, and career management. The power of women in setting career development models for men, most certainly, should not be overlooked.

37. In respect to manpower surveys, all engineering societies should be encouraged to contribute to the concept of total manpower studies, the refinement of data gathering procedures and forms, the strengthening of analytical methods, the sharpening of terms and definitions, and the better articulation of manpower functions.

38. There is an urgent need for an in-depth analysis of the relationships of the several manpower agencies now existing in the federal government structure, particularly in respect to types of data collected, methods of collection, overlaps in activity, correlations and reinforcements that are, or should be, possible.

39. Attention is called to and commendation is recommended for the exemplary manner in which the NSF Post-Censal Survey of Engineers, entitiled "The 1972 Scientist and Engineer Population Redefined", was intimately and effectively related to the on-going work of EMC and the ECPD/EJC Survey of the Profession Committee.

40. Wherever proper it is strongly recommended that the coupled terminology "ENGINEERING and SCIENCE" be used in preference to less specific but all too frequently used terminology of government, namely: "Science and Technology" in which Engineering is left unidentified and at some uncertain mid-point.

41. To plan properly, for the future, there should be a national technical manpower advisory panel with the responsibility to conceive and recommend ways and means

to stimulate national economic growth by steering new talent into fundamental manufacturing and construction areas that have had a relatively low level of R&D intensiveness.

42. There are many important manpower utilization experiences to be drawn from the highly successful infusion of science and engineering into the aerospace, computing, communications, and chemical industries. . . all of which have demonstrated well how to exploit discoveries, provide challenging new career opportunities, and make remarkable productivity gains.

43. In respect to manpower surveys, it is recommended that the concept of Relative Demand Index (RDI), be further developed on a broad basis.

44. It may be an appropriate time to reconsider the advisability of an Engineering Societies Personnel Service.

45. Engineers, engineering faculty members, and engineering students should be made more conscious of the importance to the profession of a favorable total impact in social, economic, and political affairs at community, state, and federal levels.

46. The annual Legislative Forum of major engineering societies represents an activity of much untapped potential in respect to future manpower activities.

47. Engineers are the citizens probably most conscious of the fact that only with strong and productive industrial activity will there be strong professional societies, strong educational programs, and strong government programs requiring the services of engineers.

48. The optimum program of manpower surveys and manpower development is one which makes it possible for all engineers as a vital national resource to best serve the nation.

BIOGRAPHIES OF PARTICIPANTS ON PROGRAM
ENGINEERING FOUNDATION CONFERENCE ON
"ENGINEERING MANPOWER — A NATIONAL PROBLEM OR A NATIONAL RESOURCE?"
HENNIKER, NEW HAMPSHIRE — JULY 13-18, 1975

ROBERT G. AINSWORTH

Prior to his appointment to the senior staff of the National Commission for Manpower Policy in March 1975, Mr. Ainsworth had completed more than a year as Director of the Office of Resource Requirements in the Federal Energy Administration's Office of Energy Resource Development.

He has over ten years experience in the manpower and human resources area in a variety of positions mainly in the U.S. Department of Labor. His recent experience includes Manpower Administration's Public Employment Program.

Mr. Ainsworth has taught economics at Benjamin Franklin University and the American Institute of Banking, both in Washington, D.C. He has a B.A. in Business Administration from the College of William and Mary and a M.A. in Economics from the American University.

WARREN E. ALBERTS

Mr. Alberts, Vice President — System Operations Services of United Air Lines, is a graduate of the University of Wisconsin with a BS in Mechanical Engineering and the Army Air Corps Flying School. He served five years in the Air Force during World War II, attained the rank of Colonel, and was Director of Operations for the Second Air Division of the Eighth Air Force in England.

He joined United Air Lines in 1946 as an industrial engineer and in 1947 moved to Denver as Assistant to the Vice President — Operations. On leaves of absence he acted as consultant to the Secretary of Commerce in 1951 and to British European Airways in 1953. He returned to Chicago in 1953 as Director of Industrial Engineering, was elected Vice President in 1958, Vice President and Assistant to the President in 1960 with responsibility for planning the United/Capital merger, and Vice President — Management Services and Controls in 1961. He assumed his present responsiblility for systemwide operating budgets, industrial engineering, operations research, and facility and property services in October 1971.

Mr. Alberts is President of the Engineers Joint Council and United's Computer and Communication Division.

JOHN D. ALDEN

John Alden is Director of Manpower Activities for Engineers Joint Council, a federation of 37 U.S. engineering societies. His responsibilities include conducting and publishing EJC's well-known surveys of engineers' and technicians' salaries, enrollments and degrees, and the demand for engineers.

Mr. Alden is a graduate of Cornell University with a BS degree in chemistry and also has a BS degree in electrical engineering from M.I.T. Before joining EJC he served as a career Engineering Duty Officer in the U.S. Navy, specializing in submarine construction, logistics, management and quality control.

HAROLD J. AMMOND

Harold J. Ammond received his BS in Industrial and Labor Relations from Cornell University.

Following graduation he represented various management and labor organizations, and in 1962, joined the staff of the Association of Scientists and Professional Engineering Personnel. During 1968 Mr. Ammond became Executive Director of the group which represented Research, Development and Design Engineers at RCA in the Camden, New Jersey area.

He is a consultant to other Engineering Unions such as Westinghouse and Lockheed Guild and recently organized a Buffalo Chapter of ASPEP at Worthington CEI in Buffalo, New York. He is author of various articles appearing in such periodicals as "Machine Design," and "Chemical News."

SAMUEL B. BATDORF

Dr. S. B. Batdorf is Principal Staff Scientist at The Aerospace Corporation and Adjunct Professor of Engineering at UCLA.

Dr. Batdorf obtained his Ph.D. in theoretical physics at the University of California, Berkeley, in 1938. After teaching physics for five years at the University of Nevada, he became an aeronautical research scientist at the Langley Laboratory of the NACA. During the following eight years he conducted research on various aspects of aircraft structures and published papers on elastic buckling of stiffened and unstiffened plates and shells as well as inelastic buckling. He also devised a new mathematical theory of plasticity for polycrystalline aggregates such as metals that has become known as the "slip theory of plasticity." He has subsequently filled positions at Westinghouse (Manager of Development, Materials Engineering Dept., and Corporate Director of Development); Lockheed (Assistant Director of Research, LMSD); Institute for Defense Analyses (Chairman, Man-in-Space and Communication Satellites); Aeronutronic (Manager of Research in Physics, Electronics, and Bionics); and for the last ten years has been with The Aerospace Corporation. His most recent contributions in mechanics include a new method for alleviating the sonic boom and a new statistical theory of fracture.

Dr. Batdorf is a Fellow of the American Physical Society, Fellow of ASME and past Chairman of its Applied Mechanics Division, and Associate Fellow of AIAA.

PETER CHIARULLI

Peter Chiarulli presently is Dean of Engineering and Physical Sciences at Illinois Institute of Technology. He has held academic appointments at Carnegie Institute of Technology, Brown University, and Illinois Institute of Technology and for one year was a member of the staff at the National Bureau of Standards.

Dean Chiarulli received his PhD in Applied Mathematics from Brown University in 1949.

Dr. Chiarulli is currently a Vice-President of the American Society of Mechanical Engineers. He is a member of the Board of Directors of the Western Society of Engineers and Chairman of the Board of Governors of the National Conference on Fluid Power and of the Board of Governors of the National Conference on Power Transmission. Recently he was appointed Chairman of the Board of Governors of a consortium of Midwest engineering institutions organized to develop coordinated and cooperative programs for increasing the number of minority students in engineering.

PAUL DOIGAN

Dr. Doigan currently is Manager – Entry Level Recruiting of General Electric's Professional Development Operation. A graduate of the University of Connecticut with a BS degree in chemistry in 1941, he received a second BS degree in meteorology from New York University in 1943. He completed work on his MS degree at the University of Massachusetts in 1946 and was awarded his PhD from New York University in 1950. For four years following his graduation from Connecticut, he served as a meteorologist with the U.S. Air Force, attaining the rank of Major.

Prior to joining General Electric Dr. Doigan was on the Staff of the University of Connecticut. He is a Fellow of the American Institute of Chemists and a member of the American Chemical Society; the Institute of Electrical and Electronic Engineers; the American Society for Engineering Education; Eastern College Personnel Officers, of which he is currently Vice President-Employer Relations; Sigma Xi; Sigma Pi Sigma; and Phi Lambda Upsilon.

In 1951, he joined General Electric's Transformer Laboratory Department in Pittsfield, Massachusetts. He became the Manager of Personnel Development at the Advanced Electronics Center at Cornell University in 1955, and transferred to the Missile and Space Division in Philadelphia as Manager of Engineering Administration and Facilities in 1961. In January 1967 he assumed the position of Manager – Doctoral & International Recruiting in Schenectady. In July 1974 he assumed recruiting responsibility for General Electric's Manufacturing Management, Engineering, and Co-op Programs in addition to his continuing responsibilities for activities with the schools in the Northeast and his Company-wide concern for doctoral and international recruiting. Dr. Doigan is a Commissioner on the Engineering Manpower Commission and is currently serving as Chairman of its Supply and Demand Committee.

RUSSELL C. DREW

Russell Drew currently is Director of the Science and Technology Policy Office in the National Science Foundation, a position he has held since August 1973. This office provides staff support to the Director, National Science Foundation in his new role as Science Adviser to the President and Chairman of the Federal Council for Science and Technology, an interagency sub-Cabinet level committee for coordination of Federal research and development policies.

Since 1966 Dr. Drew has held various posts in the Office of Science and Technology where he was responsible for a variety of science and technology policy matters. He was also Staff Director for the President's Space Task Group which outlined future directions for the Post-Apollo space program.

Dr. Drew received his BS degree in Engineering Physics from the University of Colorado in 1953 and his PhD degree in Physics in 1961 from Duke University. He served in the U.S. Navy from 1953-1965.

He is a member of Phi Theta Kappa, Sigma Xi, Sigma Pi Sigma, American Institute of Astronautics and Aeronautics, and is listed in *American Men of Science* and *Who's Who in Government.*

CHARLES E. FALK

Dr. Falk currently is Director, Division of Science Resources Studies, National Science Foundation, having responsibility for the development of factual and analytical information pertinent to national planning and policy formulation in the area of science and technology resources. He joined the National Science Foundation in 1966 as Planning Director.

Prior to his NSF affiliation Dr. Falk was associated with the Brookhaven National Laboratory since 1950, except for a two-year period in 1956-58 when he headed the High Energy Physics program of the Research Division, U.S. Atomic Energy Commission. His first position with Brookhaven was as associate physicist. Subsequently, he served as Administrative Scientist for the 33 Bev Alternating Gradient Synchrotron Project. After returning to Brookhaven in 1958 from his AEC assignment, Dr. Falk became successively Assistant to the Director, Assistant Director, and Associate Director of the Laboratory.

Dr. Falk received his BA degree in physics from New York University in 1944, MS in physics in 1946, and PhD in physics from Carnegie Institute of Technology in 1950. He served in the U.S. Army 1944-46. He is a member of the American Physical Society, the New York Academy of Science, the American Association for the Advancement of Science, and Sigma Xi.

MARTIN M. FRANKEL

For the past eleven years Martin Frankel has worked at

the National Center for Education Statistics of the U.S. Department of Health, Education, and Welfare on the Projections of Educational Statistics.

He attended Southeastern Massachusetts University for two years where he enrolled in the mechanical engineering program, and then transferred to Boston University where he received a BA degree in mathematics in 1964.

DEAN GILLETTE

Dean Gillette is Executive Director of the Systems Research Division at Bell Laboratories, Holmdel, New Jersey. Dr. Gillette joined Bell Labs in 1953 and was appointed Executive Director of the Transmission Systems Engineering Division in 1966. He assumed his present position in 1971.

Dr. Gillette received his BS degree in chemistry from Oregon State College, and his MA and PhD degrees in mathematics from the University of California.

He is a member of the American Mathematical Society, the Institute of Electrical and Electronic Engineers, the Society of Industrial and Applied Mathematics, the American Association for the Advancement of Science, and the Research Society of America.

ARTHUR F. HARTFORD, JR.

Arthur F. Hartford, Jr., Manager of University/Industry Relations in the Personnel Division of duPont's Employee Relations Department, has been with the Company since 1945. Originally, he was a development engineer. In 1950 Mr. Hartford entered personnel work in the Employee Relations Department in Wilmington, and at that time he was associated with the College Relations Section as Supervisor, Assistant Manager, and Manager until his current assignment in 1974.

Mr. Hartford received his bachelor's degree from Northeastern University, and served in the U.S. Navy.

He is serving a second term on the Executive Committee of the Eastern College Personnel Officers and is a member of the College Placement Council Board of Regional Governors. He is an active member of the American Society for Engineering Education, the Personnel Section of the Delaware State Chamber of Commerce, the Cooperative Education Association, and is a Commissioner and Chairman of the Engineering Manpower Commission of the Engineers Joint Council.

DANIEL E. HECKER

Daniel Hecker is currently Head, Section of Scientific and Technical Manpower, Division of Manpower and Occupational Outlook, U.S. Department of Labor. He has been with the U.S. Bureau of Labor Statistics since 1966 as a Labor Economist, responsible for developing employment data on and projecting requirements for scientists and engineers.

Mr. Hecker served in the U.S. Navy from 1962 to 1965 with the rank of Ensign-Lieutenant j.g. He received a B.A. in economics from the College of William and Mary in 1962 and an M.A. from Georgetown University in 1972.

ISRAEL KATZ

Israel Katz is Professor and Director of Advanced Engineering in The Center for Continuing Education at Northeastern University. He recently completed six years service as Dean of that Center. Since coming to Northeastern twelve years ago, Professor Katz conducted research in continuing education principles and practices. He spent fourteen years on the faculty of the College of Engineering at Cornell University as professor in charge of the Cornell Aircraft Powerplants Laboratory at Ithaca, as well as consultant to the Cornell Aeronautical Laboratory in Buffalo. During these years he was a consulting engine designer to Pratt & Whitney Aircraft. He also served as a consultant, full-time engineer and manager with the General Electric Company over a cumulative period of ten years.

Professor Katz currently is an engineering consultant to the National Academy of Sciences and to the U.S. Department of Health, Education and Welfare as well as a contributing editor on several technical magazines. He has also been active as a director of the CES Division of ASEE.

EDWARD THOMSON KIRKPATRICK

Since 1971 Dr. Kirkpatrick has been President of Wentworth Institute and Wentworth College of Technology, having previously served as Dean, College of Engineering, Rochester Institute of Technology from 1964 to 1971. His prior experience includes ten years of various professorships and seven years in industry.

He received his B.A.Sc. from the University of British Columbia and his M.S. and PhD from Carnegie Institute of Technology.

Edward Kirkpatrick is a member of ASEE, ASME, NSPE, Newcomen Society in North America, and is a registered Professional Engineer in New York and Ohio. He is a Commissioner of the Engineering Manpower Commission and serves as Vice Chairman. He is the recipient of the Distinguished Civilian Award, U.S. Army, 1971.

RONALD E. KUTSCHER

Ronald E. Kutscher is currently Chief of the Division of Economic Growth, Bureau of Labor Statistics, U.S. Department of Labor, a position he assumed in October 1968. He joined the Bureau of Labor Statistics in 1957 and in 1962 transferred to the Division of Economic Growth when the Economic Growth Model was begun. He assisted in the organization, supervision, and planning of research involved in the Model. In 1965 he was appointed Assistant Chief for Research.

He has done undergraduate work in Doane College, with major in Economics, 1955; one year graduate work in Economics at the University of Illinois, 1955-56; and

further course work in Statistics, Mathematics and Econometrics at local universities.

FRED LANDIS

Fred Landis is currently Dean of the College of Engineering and Applied Science at the University of Wisconsin-Milwaukee, a position he assumed in August 1975. During 1973-74 he was Dean of Intercampus Programs at the Polytechnic Institute of New York and before that he was for 20 years with the Mechanical Engineering Department of New York University, serving as Chairman from 1963 to 1973. He has also worked for three years in the general machinery industry in Canada and for the aircraft industry in California.

Dr. Landis received his undergraduate education at McGill University in Montreal and did his graduate work at M.I.T.

He is a fellow of the American Society of Mechanical Engineers, an Associate Fellow of the American Institute of Aeronautics and Astronautics, and a member of ASEE, Sigma Xi and a number of professional honor societies. He currently serves on the policy board of ASME.

BRYCE I. MacDONALD

Bryce I. MacDonald is Director of Engineering, Kennecott Copper Corporation, New York City. He previously held engineering and manufacturing positions with General Electric Company, and Glidden-Durkee Division of SCM Corporation.

Mr. MacDonald received his Bachelor of Chemical Engineering from Cornell University and is a member of Tau Beta Pi. He is a registered Professional Engineer in New York and a member of the Air Pollution Control Association. He is Vice President of the Engineers Joint Council and a member of the American Institute of Chemical Engineers.

NAOMI J. McAFEE

Naomi J. McAfee currently is directing the reliability, quality, maintainability, and safety engineering activities, and the failure analysis laboratory and data center for the Aerospace and Electronic Systems Division and the Systems Development Division of the Westinghouse Defense and Electronic Systems Center. Prior to this assignment she was Manager – Reliability, Maintainability and Safety Engineering.

She received her BS degree in physics at Western Kentucky University in 1956, and joined Westinghouse the same year as a mathematician in the Reliability Engineering Section.

Ms. McAfee is a senior member of the Institute of Electrical and Electronics Engineers, the American Society for Quality Control, and the Society of Women Engineers. She is listed in *Who's Who of American Women, Who's Who in the South,* and *Two Thousand Women of Distinction.* She is an ASQC Certified Reliability Engineer and a Certified Quality Engineer.

PAUL J. McGRATH

Paul J. McGrath is Director of Placement and College Relations, General Motors, Detroit. He has been associated with the Corporation Personnel Staff since 1961 having previously held a variety of positions in personnel in the Fisher Body Plant located in Syracuse, N.Y.

Mr. McGrath received his Bachelor's degree from Princeton University, having entered as a Cane Scholar. He attended graduate school evenings at Syracuse University and served two years in the U.S. Army.

DONALD B. MILLER

Donald B. Miller is Program Manager for Human Resources for the General Products Division of IBM, headquartered in San Jose, California.

Mr. Miller began his professional career with a BS in Mechanical Engineering from the University of Rochester. After designing telephone instruments for Stromberg Carlson, he went to Columbia University Graduate School of Business where he earned an MBA in Management. While at Columbia, he taught and later became an Assistant to the Dean of Engineering. During this period he took graduate studies in psychology. Joining IBM in 1952, he had many assignments including Director of Personnel for the engineering development division.

A member of ASME, SAM, IEEE, AHP, and ASEE, he has carried on extensive outside activities. He is a Fellow in the Society for Advancement of Management and past International President.

JEAN P. MOORE

Jean P. Moore has been associated with engineering education for approximately twelve years, starting with the Commission on Engineering Education which later merged with the National Academy of Engineering. The successor organization to the Commission is the Board on Engineering Manpower and Education Policy, of which she is Executive Secretary.

At the present time, Ms. Moore is assisting the newly formed NRC Committee on Minorities in Engineering to develop and implement its program and, as Chief Staff Officer for the Board on Engineering Manpower and Education Policy, is involved in the development of new projects and studies for this newly created unit of the National Research Council.

RUSSELL R. O'NEILL

Russell R. O'Neill is a Professor of Engineering and Dean, School of Engineering and Applied Science at the University of California, Los Angeles. He has held increasingly responsible positions at the University since 1946. Since 1951 Dr. O'Neill has been Principal Investigator of cargo handling research projects, now called Project TRANSIM. Prior to 1946, he was associated with the AiResearch Manufacturing Company, the Dow Chemical Company, and Dowell, Incorporated. In 1954,

Dr. O'Neill served as a staff engineer for the National Academy of Sciences – National Research Council.

He received his BS and MS in Mechanical Engineering from the University of California, Berkeley, and his PhD in Engineering from the University of California, Los Angeles.

Dr. O'Neill is a licensed Mechanical Engineer in California and is a member of the National Academy of Engineering, Sigma Xi, Tau Beta Pi, and the American Society for Engineering Education.

CAROLYN F. PHILLIPS

Carolyn F. Phillips joined Shell Oil Company, Public Affairs, as Regional Industrial Hygienist, Department of Occupational Safety and Health in December 1974.

A registered professional engineer, her most recent prior work experience was as Senior Engineer, State of New York, Department of Labor, where she specialized in industrial hygiene and air pollution control engineering. She previously served as consultant with Environmental Analysts Inc., New York, as Assistant Research Scientist at New York University Medical Center and Reactor Engineer, U.S. Atomic Energy Commission.

Carolyn Phillips earned her BME degree from Pratt Institute and her MCE degree in Sanitary/Nuclear Engineering from New York University. She has completed course requirements for her PhD in Environmental Health at New York University.

Ms. Phillips has been active in and holds elective office in a number of professional societies, including ASME and Society of Women Engineers, of which she is currently President.

K. NAGARAJA RAO

K. Nagaraja Rao is currently the Senior Research Associate of the Center for Policy Alternatives at Massachusetts Institute of Technology, a position he has held since May 1974. Previous to this he held positions with the Ford Foundation, Dunwoody Industrial Institute, Institute of Gas Technology, Illinois Institute of Technology and the University of Mysore, India. He has had several international assignments in Latin America, Indochina and Africa.

Dr. Rao received his PhD in 1950 from the Illinois Institute of Technology in Chemical Engineering, and his BS and MS in Physical Chemistry from the University of Mysore, India. He is a member of the American Institute of Chemical Engineers, and the American Association for the Advancement of Science.

DAVID R. REYES-GUERRA

David R. Reyes-Guerra is currently Executive Director of Engineers' Council for Professional Development. In addition, he serves as Executive Director of the Junior Engineering Technical Society.

Mr. Reyes-Guerra has represented the engineering education profession at the White House Conference on Children and Youth. He served as Director of the International Programs for the Engineers Joint Council in 1970 and was Guidance Director for ECPD from 1968 to 1972. Prior to his present position he was an Instructor in Engineering at the University of Illinois and a project engineer for the United Fruit Company's Central American operation.

He was graduated from the Escuela Preparatoria in Guatemala with a Bachelor of Science degree, and received a Bachelor of Engineering degree from The Citadel and a Master in Engineering degree from Yale University. He is currently Secretary-Treasurer of the UPADI Fund (Pan American Federation of Engineering Societies), and a member of the American Personnel and Guidance Association, the National Society of Professional Engineers, the American Society of Civil Engineers, the American Society for Engineering Education, and the National Science Teachers Association. Mr. Reyes-Guerra is currently serving as a Commissioner on the Engineering Manpower Commission.

HAROLD E. ROUSH

Harold (Bud) E. Roush, Director, College Relations, for RCA Corporation has been with the company since 1966. He has held various positions on the Corporate Staff concerning college relations, campus relations, college recruiting, and management programs for recent graduates. Prior to joining RCA he held positions with the Hamilton Watch Company and Link/Librascope Ordnance Division, General Precision, Inc., and served in the U.S. Navy from 1954 to 1957.

Mr. Roush received his BS degree in Mechanical Engineering from Penn State University in 1954 and is a registered Professional Engineer of the State of Pennsylvania.

He is a member of the College Placement Council, American Assembly of Collegiate Schools of Business, Engineering Manpower Commission, the American Society for Engineering Education, the Cooperative Education Association, and the American Defense Preparedness Association.

NORMAN SELTZER

Norman Seltzer is Study Director of the Manpower Utilization Studies Group, Science Resources Studies Division of the National Science Foundation, responsible for studies and surveys pertaining to the supply, employment, and utilization of scientists, engineers, and technicians in the entire economy.

He started his career as a labor economist with the Bureau of Labor Statistics in Washington, D.C. where he remained for six years; then he became an industrial relations analyst with Ford Motor Company for four years. Sixteen years ago he became a professional analyst at the National Science Foundation in the Division of Scientific Personnel and Education.

Mr. Seltzer has a bachelor's degree in economics from the City College of New York, and a Master's degree in labor and industrial relations from the University of Illinois.

WARREN C. STOKER

Since 1974 Warren C. Stoker has been President and Trustee of Rensselaer Polytechnic Institute of Connecticut. He served as Vice President and Trustee since 1961. Previously he served as Dean of the Hartford Graduate Center and Associate Dean of the Graduate School in Troy, Director of the Center, Director of the Computer Laboratory and Professor of Electrical Engineering, having joined the Rensselaer faculty in 1934.

Dr. Stoker received his BS, MS and PhD degrees in electrical engineering from Rensselaer Polytechnic Institute.

He is a member of the American Society for Engineering Education, American Association for the Advancement of Science, Newcomen Society, Sigma Xi, RESA, Eta Kappa Nu, and Tau Beta Pi. He is a Fellow of the Institute of Electrical and Electronic Engineers, and is a member of the Hartford Club.

MELVIN W. THOMPSON

Mr. Thompson is currently the first full-time Executive Director of the National Research Council's Committee on Minorities in Engineering, a post he assumed on October 1, 1974.

He previously headed the minorities program at New Jersey's Newark College of Engineering. During his five years on the Newark campus, the college's minorities enrollment experienced a dramatic tenfold increase—from 20 to 200 students. He was employed in secondary education in Columbia, South Carolina, and Paterson, New Jersey, before his Newark assignment. In recent years, Mr. Thompson has worked with the Minority Engineering Education Effort (ME³), the New Jersey Science Coalition, and served as a consultant to several college and university minority programs.

Mr. Thompson holds a master's degree in chemistry from Syracuse University and took graduate studies at the University of Cincinnati and the University of California at San Diego.

MYRON TRIBUS

Dr. Myron Tribus is proposed for appointment as Professor of Engineering in the School of Engineering and Director of the Center for Advanced Engineering Study at M.I.T.

He was a member of the faculty of the Engineering Department at University of California at Los Angeles from 1946 to 1950 and from 1953 to 1961. In 1961 he became Dean of the Thayer School of Engineering at Dartmouth College. In 1969 President Nixon nominated Dr. Tribus to the position of Assistant Secretary of Commerce for Science and Technology, where he was in charge of the National Bureau of Standards, Environmental Sciences Services Administration, Patent Office, National Technical Information Services, Office of Telecommunications, and Office of State Technical Services. From his role of public servant, he joined the Xerox Corporation in 1970 and served as a vice president on Xerox's Corporate Research Staff.

Dr. Tribus received his BS degree from the University of California (Berkeley) and his PhD from the University of California (Los Angeles). He received an honorary MA degree from Dartmouth College and honorary ScD degrees from Rockford College and Oakland University.

MAC ELWYN VAN VALKENBURG

Mac Elwyn Van Valkenburg is Professor of Electrical Engineering and Research Professor, Coordinated Science Laboratory, University of Illinois at Urbana-Champaign.

Formerly he was associated with Massachusetts Institute of Technology, University of Utah, Stanford University, Princeton University, and he had visiting appointments at University of Colorado, University of California at Berkeley, Indian Institute of Technology, Kanpur, and University of Illinois. Dr. Van Valkenburg is a member of National Academy of Engineering; past Vice President and Director and Fellow of IEEE (Education Medal, 1972); Member, Advisory Committee on Research, National Science Foundation, 1971-1974; Member of Commission VI of International Union of Radio Science (URSI); member of American Society for Engineering Education, Tau Beta Pi, Sigma Xi, Phi Kappa Phi, and Eta Kappa Nu.

Dr. Van Valkenburg received his BS from the University of Utah, his MS from MIT, and his PhD from Stanford University, all in electrical engineering.

CORNELIUS WANDMACHER

Cornelius Wandmacher during the past year served as national President of the American Society for Engineering Education. He recently concluded a term of twelve years as Dean, College of Engineering, University of Cincinnati. He is continuing his role in University affairs as Professor of Engineering Education.

Dr. Wandmacher has served several terms as a member of the Board of Directors of the Engineers' Council for Professional Development. In 1963 he was appointed by the Governor of Ohio to the Ohio Board of Registration for Professional Engineers and served two five-year terms.

Professor Wandmacher's experience includes brief periods of engineering practice with various industries and the Municipal Civil Service Commission of New York City.

He is a graduate of the Polytechnic Institute of New York where he received an early fellowship for graduate study and later became a faculty member and administrative officer. He is a Fellow of the American Society of Civil Engineers.

GEORGE D. WHITE

George D. White is currently the Regional Federal Equal Employment Opportunity Representative for the U.S. Civil Service Commission in Boston, Mass.

(Further biographical information was not available at press time.)

GEORGE P. WOOD

George P. Wood is the Director – Urban Relations for Martin Marietta Corporation. He joined Martin Marietta's Customer Education Department at their Baltimore Aerospace Division in 1956. Later, he was the Director of training for the Gemini Launch Vehicle Program and chief of Logistic Support at the Aircraft Modification Facility. In October 1967, Mr. Wood was loaned to the Plans for Progress national staff in Washington and upon returning a year later, he became Administrator – Minority Relations, and moved to his present position in April 1972.

Mr. Wood received his BA from Pennsylvania State University and BS from the University of Baltimore. He is a member of the American Society for Training and Development, Chairman of the Manufacturing Management Council of the Society of Manufacturing Engineers and a Commissioner of the Engineers Joint Council's Engineering Manpower Commission.

VINCENT PAUL WRIGHT

Vincent Paul Wright is Manager, Management Development Program for Stone & Webster Engineering Corporation. From 1969-1973 he was Executive Vice President of Stonehill College and from 1967-1969 Dean of Faculty at Southeastern Massachusetts University. Prior to that he served as Dean of Graduate and Undergraduate Schools of Business at the University of San Francisco, and Dean of Graduate Schools of Business at Boston College and Northeastern University. He was with the Department of Economics at Boston College and served in the U.S. Navy.

Dr. Wright received a D.H. (hon.) from Stonehill College, a D.B.A. (hon.) from New Bedford Institute of Technology, and a BS, MA, and Ed.D in Economics and Research from Harvard College.

ROGER MAX ZIMMERMAN

Roger Max Zimmerman is Professor of Civil Engineering and Acting Dean of Engineering at New Mexico State University, having held various positions at the University since 1964.

Dr. Zimmerman received his BS, MS and PhD degrees from the University of Colorado, Boulder.

He is a member of ASCE, ASEE, ACI, Sigma Xi, Chi Epsilon, Sigma Tau, Tau Beta Pi and is a registered Professional Engineer in New Mexico. He has received the Outstanding Educator of America Award and the Dow Chemical Company Young Faculty Delegate Award.

PART III
TEXTS OF THE PAPERS PRESENTED AT THE CONFERENCE

WHERE WE ARE TODAY — A VIEW FROM THE ENGINEERING PROFESSION

by John D. Alden
Executive Secretary, Engineering Manpower Commission
Henniker, New Hampshire
July 14, 1975

In assessing the engineering manpower picture as it appears today, other panelists will describe ongoing programs within the federal government and the practices followed by a major employer. I would like to take a dual approach, first to review some of the activities being conducted by professional organizations, and second to give you an overview of the situation as I see it in industry, education, government, and the engineering profession itself.

Manpower Activities Within the Engineering Profession.

There has been a resurgence of interest in the various aspects of manpower utilization on the part of organizations within the engineering profession. In several societies this has resulted in the establishment of manpower committees, and these in turn have implemented or recommended actions to be taken by the individual societies. Generally speaking, the activities of the societies have focused on such bread-and-butter issues as salaries, fringe benefits, unemployment, job availability, and continuing education to combat obsolescence. As would be expected, these activities are oriented almost exclusively toward members of the particular society. Because the interests, needs, and resources of the societies vary widely, the manpower activities of each one are conducted independently of the others. From each society's point of view, little if any benefit would be obtained by, for instance, adopting a standard set of questions and definitions or conducting all employment surveys simultaneously. It is therefore impossible to gain a comprehensive overall picture of engineering manpower from the activities of the individual societies, and unrealistic to expect these activities to evolve into a professionwide source of manpower information. The society programs do, however, constitute a useful source of data for checking, corroborating, or helping to interpret the results of other nation-wide manpower surveys.

On a broader basis, the Engineering Manpower Commission of Engineers Joint Council carries out a number of periodic surveys covering selected aspects of the manpower picture for all branches of the profession. These include the following:

Annual surveys of degrees granted and fall enrollments in engineering and technology programs in U.S. educational establishments.

An annual survey of the placement status of the engineering and technology graduating class.

Biennial surveys of the salaries of engineers and engineering technicians.

Semi-annual surveys of job openings and plans on the part of employers to hire engineers during the year ahead.

Special analyses of women and minority members among students and new graduates.

Examples of the reports resulting from these surveys are on display and available to participants in this conference.

I would like now to shift my focus from the ongoing activities within the profession to an overall look at the situation as it appears from my particular point of view.

Engineering Manpower and Industry.

Employers represent the source of manpower demand, and industry is by far the largest employer of engineers and technologists. The state of engineering employment today is little short of chaotic. For the last five years the demand for engineers has been going up and down like a yo-yo. 1970 was a year of cut-backs and layoffs, producing in 1971 the highest rate of unemployment among engineers since the Great Depression. By 1973 recovery was underway, and in 1974 recruiters were falling over each other in the competition to hire new college graduates. Last winter, however, the bottom fell out of the job market. Companies cut back their hiring plans drastically and clouds of uncertainty descended once more on the nation's campuses. Throughout this period the picture has been complicated by counter-trends in some industries and some specialties. Just as we have been faced with simultaneous recession and inflation on the national economic scene, so have we had manpower shortages in the face of layoffs and unemployment. The general attitude of engineering employers today, as I see it, is one of immediate caution and retrenchment, and great uncertainty as to the future.

Engineering Manpower and Education.

Our colleges and universities represent the principal source of supply for new engineers and technologists. In reaction to the fluctuations in demand for engineers, enrollments plummeted by 27 percent in a period of only two years until the freshman class in fall 1973 was the smallest in over 20 years. Last fall the trend reversed itself as students rediscovered the fact that jobs were more readily available in engineering than in most other fields, economic ups and downs not withstanding. Unfortunately, the long time lag between initial enrollment and graduation makes it virtually impossible to match the input of new graduates into the engineering work force to the demand existing at the time of graduation. For the next four or five years, we can anticipate rather wide fluctuations in the manpower supply due simply to the varying sizes of the classes currently enrolled in our engineering schools.

Qualitatively, the educational establishment is going through a painful reassessment of the objectives and content of an engineering education. For years employers have been complaining that the schools were not producing the kind of graduates needed to fill existing jobs, while the educators have responded that they were

producing the engineers that industry would need for the next 30 years, not just to fill the immediate requirements of the present. Recently the four-year engineering technology programs started expanding to fill the gap, and today a major debate is underway as to the proper role of each type of educational program in the technical manpower spectrum. Engineering education thus finds itself in a period of conflicting requirements and uncertainty about the future.

The Individual Engineer

In the middle stands the individual engineer or engineering technologist, for whom the fluctuations of supply and demand take on a highly personal meaning. National data cannot measure the extent to which a single engineer's job is secure or his work professionally satisfying. To the individual, employment statistics such as a nationwide unemployment rate have no meaning. The reality is that approximately ten thousand engineers are out of work for each percentage point in the unemployment rate, and to each one the effective unemployment rate is 100 percent. In today's climate of uncertainty and sudden changes, many engineers feel that they have no control over their own destiny, and that their real situation is not consistent with true professional status. Their insecurities and frustrations are being manifested in grass roots pressure on the engineering societies. Many are calling for the erection of barriers to restrict new entrants into the profession. Others seek greater security through higher salary scales, the regulation of employment practices, and collective bargaining. Large numbers are demanding that the profession, through its organizations, provide more services to assist individual engineers in their career advancement. Women and minority members are actively seeking greater professional representation and recognition. There is a growing feeling of restlessness, discontent, and pressure for change.

Engineering Manpower and the Government.

When the Engineering Manpower Commission was organized nearly 25 years ago, federal policy was based on the premise that engineers and scientists constituted a limited and valuable national resource. In the last few years they have come to be seen more as a national problem, as one of many annoying pressure groups to be appeased while our legislators and government executives get on with the more important business of running the country. The question of re-establishing a high-level science advisory function is being treated as a political struggle between Congress and the President, and one wonders whether either party is seriously interested in introducing sound technical advice into the national decision-making process.

At the departmental level some good basic work is still being done. You will hear much about this from other speakers at this conference. But every department and agency is restricted by policy directives and fund limitations imposed from above. The term "manpower" has come to be applied almost exclusively to programs aimed at providing basic skills to the unemployable. The educated professions are expected to take care of themselves.

If scientists have become the government's stepchildren, engineers are its orphans. On the one hand is a tendency to concentrate on the uneducated, "underprivileged", unskilled worker. On the other extreme engineers feel that most of the attention being given to the scientific and engineering community is focused on the research function and the PhD educational level. Some 90 percent of the nation's engineers and technologists fall outside the scope of these major government interests. All too often we find "engineers and scientists" or "scientists, engineers, and technicians" lumped together in national statistics and policy statements as if the contributions of each group were interchangeable or their problems were indentical. The major branches of engineering are even less frequently singled out for separate consideration. All in all, engineers feel that the government doesn't really understand them and doesn't much care what they say or do as long as they perform whatever technical work is assigned to them.

Engineering Manpower and the Profession.

The organization of the engineering profession has never been easy to understand even by its members. As a measure of its diversity, consider the organizations listed as sponsors of this conference. All but one are independent, sovereign institutions. The exception, the Engineering Manpower Commission, is part of a larger entity, Engineers Joint Council. The prime sponsor, the Engineering Foundation, stands apart from the other societies as a purely charitable institution. The co-sponsors include two federations and 20 individual membership societies with varying degrees of interrelationship. The number of organizations represented here could be doubled, tripled, or quadrupled without exhausting the list of recognized engineering societies, but I am pleased to report that the 10 largest societies are included. Two other important organizations must be mentioned. The National Academy of Engineering, for policy reasons, could not be an official co-sponsor, but several of its key people participated in the planning and are on the conference program. The Association for Cooperation in Engineering (ACE), the newest "umbrella" organization in the profession, acts as a clearing house for its member societies but does not carry on substantive programs under its own name. Although ACE and the Academy are not official sponsors of this conference, their interests are well represented among the attendees.

Each of these engineering societies represents a particular segment of the profession, but all of our societies together include not quite half of all U.S. engineers in their membership. The other half have no known affiliation with a professional organization.

All of the societies are working toward ends that they

believe to be for the good of the profession. Some see the dissemination of technical knowledge as their primary function: Others believe that it is more important to improve the status and working conditions of their members. The problem is that on almost any issue some societies or splinter groups will take opposite sides, while others may be completely disinterested. As a result we find various shifting combinations of engineering organizations making public statements or offering testimony to Congress in the name of the engineering profession, but in actuality representing only a limited section of the profession. I do not believe that Congress, the press, or the American public understand the organizational complexities of the engineering profession or are able to distinguish one spokesman group from another. Until the profession learns to speak more clearly with one voice, I am afraid its messages will largely be lost in a Babel of competing tongues.

What We Do Not Know Today About Engineering Manpower.

In conclusion, I would like to invite your attention to what I think are the most serious gaps in our knowledge. You will hear a lot about what various agencies and organizations are doing, but here are some of the things that are missing.

We do not know, with meaningful accuracy, whether total engineering employment is growing or contracting, let alone the situation in particular specialties or industries.

We do not know how many engineers, both experienced and new graduates, are unemployed or involuntarily underemployed.

We do not know how many job openings exist or where they are, so that available engineers could seek to fill them.

We know a lot about the characteristics of the engineering population of 1970, but little about today's population.

We know practically nothing about the employment and utilization of bachelor of technology graduates, as the occupation of engineering technologist is not identified in national manpower statistics.

We have only a sketchy knowledge of employers' hiring plans.

Our ability to project future manpower supply and demand is so poor that many past efforts have been more misleading than helpful.

Although this is where we are today, it is not inevitable that we stay here. All of the deficiencies I have cited are susceptible of improvement, and many could be largely resolved using known methods and tried techniques. As we move ahead in this conference I urge that all of us shift our concentration from where we are today to where we ought to be and can be in the future. The conclusions and recommendations that we develop will be instrumental in determining our new goals and finding ways to reach them.

CONCERNS OF ENGINEERS

by Roger M. Zimmerman
Monday, July 14, 1975

The subject of today's discussion on Engineering Manpower, Where Are We Today?, has brought forth a number of significant points by the speakers. Since a number of significant items have been addressed, I will attempt to relate to the concerns of engineers that have not been previously discussed. For reference, I will summarize the major points of the previous speakers in the following paragraphs.

Dr. Myron Tribus, the keynote Speaker, discussed Engineering Manpower at the Crossroads. He indicated that problems stemmed from four principal sources. First, he is concerned that engineers do not have influence at the national level in technical advising. Many government agencies lack the planning and identification of goals that reflect technical contributions that engineers could and should participate in. Second, he feels that there is a failure in academia to comprehend the changes in engineering. He points out that most of today's engineers are graduates from engineering colleges and he is concerned that today's educators are emphasizing the engineering science-type subjects rather than the applied engineering or system engineering-type subjects that are needed in today's practice. Third, he is concerned that there is a decline in labor and technical production nationally. With the scarity of raw materials and energy there is not the increased manpower production that will be necessary to properly develop and utilize them. His final point was a note of the absence of engineering in national policy decision making. Part of this is the erosion of the self-image of engineers as they mature and their tendency to turn inward rather than outward.

Dr. Charles Falk spoke of the problems of identifying the engineering population and of his efforts with NSF to determine their functions and their educational levels within the nation's labor force. Mr. Paul McGrath from General Motors discussed the problems of utilizing properly large engineering populations in industry. Some engineers are working as foremen in the assembly plants while others are working in engineering related jobs. GM is trying to model the functions and needs of technical resources through a manpower information system to improve on this. Mr. Norman Harvey, of the Manpower Administration, discussed the various federal acts related to the establishment of technical and labor manpower programs. Mr. John Alden discussed the role of the professional societies in engineering, and commented on their independence, which has caused disorganization in the engineering profession. He then discussed the changes that are occurring in the technical manpower areas and the current gloom that appears. He reflected on the mismatch between enrollment changes in engineering schools which are too often out of phase with the manpower needs of industry.

Mr. Bryce MacDonald of the Kennecott Copper Corporation discussed concerns of engineering and com-

mented on six problems that affect young and mature engineers. These six problems deal with compensation, financial security, job challenges, personal recognition, political impact, and professional ethics. He articulated the feelings of the older engineers and the younger engineers on these six items. He felt that compensation problems for engineers possibly will diminish with the increased potential for organized bargaining. He further sees a conflict between the stability of employment of engineers and the free enterprise system. Mr. Harold Ammond discussed the latest activites that deal with the organizing of engineers into labor groups. He personally represents a number of engineers who are organized at RCA. The latest changes are that in California, 3,000 McDonnell-Douglas engineers voted to affiliate with the Teamsters Union for their collective bargaining. Further, 1,200 Convair employees are now affiliated with the United Auto Workers in their bargaining. His observation is that the problems of lack of security caused by layoffs, salary compression, costs of living, and merit problems are driving engineers into organized labor. The question is will they remain professional labor groups or will they become part of the larger labor unions such as the Teamsters. Ms. Naomi McAfee reflected on the concerns about the recruiting of engineers with changing manpower demands. She spoke of the difficulties in recruiting engineers, particularly women, and she spoke of the feelings of women as they view the manpower and professional changes that are occurring at this time. The reversed discrimination aspects that are occurring are becoming of more concern to a number of women in engineering.

With this as a background, I wish to discuss some items that are of concern to me that have not previously been noted in this initial session for this conference. My first concern is the image and identification of the engineering profession. There are questions as to whether engineering is a profession or a business. Statistics seem to indicate that engineering is an employee profession. That is, the large majority of engineers work for someone else. In this context the word profession appears to be more identified with the defintion as described under the Taft-Hartley Law of 1947. In this case a professional employee was defined in order to separate white collar workers from blue collar workers. Ideally, it would be nice to discuss the engineering profession as a single unique group for which status has been achieved by some mechanism other than this definition. Statistics are limited but it is apparent that there are approximately one million persons who qualify as engineers under the Taft-Hartley law and yet, only 330,000 of these are EIT's and PE's. Further, of those who are in this last category, only 70,000 have identified with the group called the National Society of Professional Engineers. The fact that a small number have chosen to be legally licensed as registered professional engineers and a much smaller number affiliated with NSPE makes it apparent that there must be many persons who are qualified and are functioning as engineers but who have not chosen this method for being recognized. This larger group consists of those who are predominately dealing with engineering as related to the marketing of products, which do not involve the protection of the public safety. By state laws, these engineers do not need to be licensed professionally.

Within the broad spectrum of the engineering profession, another observation should be commented on. Civil engineers represent approximately 14% of the engineering manpower. Of these, roughly two-thirds are registered professional engineers and approximately 30 percent of these work in private practice either as a principal or an employee. Another 40% work with a state or federal government and approximately 23% work in industry. Other major groups of engineers including mechanical, electrical, and mining have different functional distributions. Only 10% of any of these are in private practice and the same figure holds for their employment in government. From two-thirds to three-fourths of non-civil engineers work in industry thus indicating a large difference between their function and that of the civil engineer. In these latter groups it is noted that no more than one-third of any of these engineers are registered professional engineers.

This indicates that the majority of engineers are working for industry largely as employees and that they are not achieving a form of professional status through the registration process. Part of the confusion in the identification of engineers can be attributed to the fact that NSPE has set up professional recognition standards that are more geared for those engineers in private practice who protect the public safety. This best fits many of the civil engineers. This situation is similar to the architects, lawyers, and medical doctors where approximately two-thirds of the practitioners are in private practice. The apparent fact is that the largest number of engineers are working in industry and have employment patterns that are dissimiliar to other organized professions.

It is also noted that engineering is the second largest legally recognized profession according to the 1970 census. The largest profession is that of public school teacher which accounts for nearly three million persons. The next largest profession to engineering with approximately 1,000,000 persons, is that of accounting which has roughly 800,000 persons, while college teaching is comprised of approximately 500,000 persons. Physicians and lawyers are at the 300,000 membership level. Certainly the status of a large employee profession is starting to take on the appearances of the largest profession – public school teaching – and such things as collective bargaining, etc. are being seriously discussed by engineers. With these observations, I am concerned about the engineering profession and how it can best serve a useful role in society composed as it is.

Another concern that I feel must be brought out at this meeting is the role of engineering technicians and technologists in the engineering manpower planning reports, as it is felt that they are rapidly taking an increasingly more significant role in the technical manpower picture. For example, in 1967 there were 77,551 engineering

students in 274 ECPD accredited schools. For the same year there were 13,877 technology students in 38 schools having ECPD accreditation. In 1974, there were 63,444 freshman engineering students in 282 schools while there were 23,348 freshman technology students, and now 96 ECPD accredited schools. These figures indicate that the engineering technician and technologist program is growing quite rapidly and soon should assume an important role in engineering manpower functions. Limited studies indicate that at one time, roughly a decade ago, there were approximately two engineers for every technician. Suggestions are that for our technical manpower to be efficient, there should be roughly two technicians for every engineer. It has been indicated that in the communications industry today, this ratio is roughly 2.37. For reference, these persons can perform drafting, estimating, field service, inspection, installation, surveying, technical writing, testing, time study, tool design, and maintenance functions that probably are being done by some engineers today. It is my observation that industry has not really discovered the availability and the capabilities of the engineering technicians, and when they do there will be opportunities for these graduates that will be widely advertised and this could have a significant impact on the number of engineering students that are being graduated. Young engineers are being prepared for career functions and growth while engineering technologists are being prepared to solve problems that are different in scope and nearer in the future. This should be an attractive product for industry. The concern that I wish to express is that engineering technicians and technologists should be considered as a functioning part of the engineering manpower picture and with this will come subsequent impacts on industry and the educational institutions.

My third concern is tied to a previous point that has been made this morning regarding the erosion of engineering talent as young people proceed through their careers. This was highlighted by Dr. Tribus. He commented that some engineers have given up, their spirits are broken, because they are tied to the engineering manpower picture and layoffs are a worrisome thing. Further, it is reported that some engineers' productivity decreases after approximately 20 years and that they are ready to be pushed out while other, young, engineers are actively being recruited to take their places. These and many other problems are situations that engineers are facing. The increases in the activity of collective bargaining reflects these symptoms. These concerns are real and should be addressed. My concern is on the direction that the practitioners of the engineering profession are taking in their efforts to better themselves.

I do not feel that collective bargaining is the route that should be taken and I propose that an alternate means be employed. In the educational institutions, the Engineers' Council for Professional Development accredits various engineering curricula. The engineering profession collectively is represented through the technical societies to ECPD and this group attempts to define the criteria that should be achieved in the various engineering schools in order to recognize programs and prepare resulting graduates. Accreditation is voluntary and is asked for by the schools, but a stamp of recognition by ECPD gives stature to the school and helps the school maintain its educational programs along constructive and professionally developing lines. Input to the schools is made by an outside agency with professional society involvement and helps to stabilize the educational efforts. My proposal is that we set up an accreditation procedure for industry designed to evaluate their career development programs for engineers. This accreditation would be voluntary and representation by industry would be made through the professional societies to ECPD just as in the college programs. It is felt that there are many areas that are overlooked on a broad basis by the industries' lack of involvement with professional societies and the other groups who are concerned about the welfare of the employees. For instance, many industries have continuing education programs for their employees that are directed specifically towards the technical skills improvements that are needed for the job immediately at hand. There generally is very little pattern as to how these are useful in building a career for an engineer. The suggestion that engineers become obsolete after 20 years is a serious concern that has to be addressed if it is anywhere near true. If this accreditation were defined for career development, then possibly the full talents of engineers could be developed in industry through their careers in engineering. Now, the logical next step for this is that salary negotiations would become an important part of such an accreditation scheme. I feel that recognition and stabilization in career development and the programs and functions that industry puts into this would be beneficial, just as similar items apply to educational institutions now. In educational institutions we would not want ECPD to comment on our grading procedures or specify the number of hours that are required for a degree. I feel that salaries fit in this latter category and that this should not be included as a criterion for recognition. That is, then, I do not suggest that this accreditation become a means towards creating pressures like collective bargaining, but that it would more address those items which deal with career development of engineers. An attractiveness to this procedure would be that a list of industries that are accredited by this means would be available to prospective graduates and this would help them in their selection of a company for employment. An accredited career development program that was designed to benefit the young engineer would be an attraction to graduates and should help them significantly in their career as an engineer.

(Reference data tables follow)

REFERENCE DATA

1970 Census Data

Occupation	1970 Census Population
Teachers (elementary & secondary)	2,774,800
Engineers	1,230,500
Accountants	812,000
Teachers (college & university)	490,700
Physicians & Surgeons	281,700
Lawyers & Judges	273,500
Dentists	91,000
Architects	56,900

Source: THE ENGINEER AND HIS PROFESSION, J. D. Kemper, Holt, Rinehart, Winston, 2nd Ed., 1975, p. 97.

1964 Engineering Employment Categories by Discipline

Area of Practice	ASCE	AIME	ASME	IEEE	AIA	ABA	AMA
Private Practice (Principals & Employees)	29%	9%	10%	10%	66%	76%	63%
Government (Federal, State & Local)	40%	4%	9%	9%			
Industry (Including Construction)	23%	76%	73%	68%	32%	24%	37%
All Other	8%	11%	8%	13%			

Source: THE AMERICAN CIVIL ENGINEER, W. H. Wisely, ASCE, 1974, p. 148.

1975 Engineering Registration Statistics

Discipline	Approx. No. Engr.	% Registered	% Prof. Soc.
Civil	140,000	64%	55%
Chemical	50,000	23%	62.5%
Electrical	220,000	22%	50%
Mechanical	190,000	33%	50%

Source: Memo to ASCE Board of Directors, E. Zwoyer, File 1-7-1, Apr. 1975.

1975 Educators Registration Information

Academic Rank	Approx. % Registered	Approx. % Member NSPE
Dean	70%	35%
Dept. Head	60%	20%
Prof.	50%	15%
Assoc. Prof.	40%	10%
Asst. Prof.	20%	5%

Source: THE ENGINEERING EDUCATOR & COLLECTIVE BARGAINING, J. B. Blackburn, NSPE Engineer in Education Newsletter, Vol. 10, No. 1, Spring 1975.

NATIONAL SCIENCE AND TECHNOLOGY POLICY

Remarks of Dr. Russell C. Drew
Director, Science & Technology Policy Office
National Science Foundation
(as delivered)

at the

Engineering Manpower Conference
Henniker, N.H.
July 16, 1975

It's a particularly challenging task to follow Myron Tribus and Warren Alberts and the people who have been on this podium earlier in the Conference, especially when I am representing one of the "bad guys" on the scene – the U.S. Government and its policies, or lack of them, in the manpower area. But I think it is helpful to understand the government point of view as I am able to express it to you today and perhaps you may be able to draw from it some better insight into the problems that we have in Washington in dealing with a complex and very difficult area—the area of science and technology manpower. I am afraid I will be guilty of the sin that one of the earlier speakers mentioned, and that is of talking of engineers as part of the science and engineering manpower question. I'm afraid that that's the way it's looked at in Washington, and perhaps there is a lesson that needs to be brought home more forcibly to us on our side, and that is to make a distinction between scientists and engineers.

This morning I am going to touch on four major elements of the science and technology policy picture as it applies to manpower. First I am going to describe some of the policy options—the tools, the way in which government has taken action with respect to the manpower question. Then I am going to spend a little time talking about the structure—that is the people and the institutions on the Washington scene, many of which are changing and in the process of change, that will have a bearing on what is decided and what is done from the standpoint of the Federal Government. Third, I am going to try then to relate some of the concerns that you have expressed to that structure and give you a few comments about how one might relate to the structure in Washington. Finally, I will catalog some trends that have been emerging on the Washington scene lately that have a bearing on this problem.

First, let me take some liberty with a story of my own to add to Warren Alberts' story of the crossing of the Atlantic from west to east. This one I think will fit in quite appropriately. This story takes place many years after Warren's story, on a jet aircraft which is going from Europe to the United States, and as the aircraft leaves the shore of England, the Captain comes on the intercom and says, "Achtung, Goot morning, Ladies and Gentlemen, we welcome you to Lufthansa flight 145 from Bonn to New York City. We are cruising at 39,000 feet and I hope you all sit back and enjoy a very pleasant flight." The people, of course, do and the cocktails are beginning to be served. Pretty soon there is a sort of downward lurch and the Captain comes on, "Achtung, this is the Captain speaking. We have had some small problem with our engines, we are going to be descending but there is nothing to worry about." The people take this in their stride, but they are a little bit more alert. A few moments later the Captain comes on again and says, "Achtung, this is the Captain speaking. We have some very serious trouble with the engines, we are not able to hold altitude, and we are going to have to land in ze water. I would like to have all of the passengers follow the following instructions. First, I would like to have all of the people who are swimmers sit on the righthand side of the airplane; all of the people who are non-swimmers sit on the lefthand side of the airplane. Now, for the people on the righthand side of the airplane, after we land, England will be 30 miles off the right wing. For the people who are sitting on the lefthand side of the airplane, thank you for flying Lufthansa."

To many of you the Federal attitude toward science and engineering manpower is very much the case of "sink or swim." And I think that's an unfortunate attitude for the community to have. I've heard it in a number of remarks that have been made in working sessions and in the questions and answers. There seems to be a feeling that the people in Washington don't care or they are uninterested in the problems of science and particularly engineering manpower. That's, of course, not so, but many of the things that are done, or particularly are not done, seem to give that impression. I think what that illustrates is the need for some better intra-government/-private sector-business/university community communication. Now one very serious deficiency on the Federal government's side is that science and engineering manpower per se has no single home. If you are familiar with the operation of government, an issue which has many homes turns out to have essentially no home, because it's very easy to turn over to someone else the responsibility, or feel comfortable about the fact that someone else is doing that job. So the need for a better focus within the Federal government on these problems is a very clear one and I would think the policy statement by the EJC on engineering manpower that was distributed at this session is quite relevant in that regard on the recommendation for better focal point in government. I think there is a possibility for that and I will get to it later on. The Federal role in dealing with science and engineering manpower, however, has been rather significant, and I would just like to catalog for you some of the ways in which the Federal government has been involved. These are not new to you but I think it is useful to review them because I want to lead then into the area of what the Federal government has *not* been doing, generally because of the philosophy of what is an appropriate role for the Federal government. First of all, the Federal government is involved with gathering and disseminating statistics about manpower

and doing certain analytical jobs with those statistics, and Charlie Falk's office is a principal source of that as well as the Bureau of Labor Statistics and other places in government.

Second, the Federal government has a role in improving the quality of the educational system—that is the process by which the information flows into the budding engineers at college and graduate school. The National Science Foundation in this area has played a very important key role in upgrading the curriculum both at the pre-college, college, and post-graduate levels. NSF similarly has supported the training of qualified people. This is not a strictly NSF function, but it has been carried out by most of the R&D oriented mission agencies at one time or another. You are all quite familiar with the role that NASA played in this regard during the early and mid sixties. The NSF continues to play that type of role in providing training support, and HEW also has a very significant program. In addition, the Federal government has played a very strong indirect role in creating the pull for engineers and their use in society through the very large scale development programs which appear on the scene and, as somebody pointed out, disappear with, I suppose, an equal regularity and sometimes with a rather abrupt effect on manpower. This is, of course, a very serious problem, one which I think Federal agencies do not appreciate adequately.

There are a number of other areas in which the Federal government plays a role in this regard for example through standard setting. A greater and greater Federal regulatory function is now impacting the engineering community, either because of safety, or because of environmental requirements, or perhaps simply because of the antitrust provisions, the need to provide a sort of regulated industry, and limited entry for activities where the capital costs of entry are very large. This is particularly true in communications areas.

The Federal government is also active with respect to employment and unemployment and we have heard about the Department of Labor programs in this area. These are all part of the accepted Federal policy roles in dealing with science and engineering manpower problems.

Let's go on to see what the Federal role has not been. First of all the Federal role has not been to limit the number of people entering the field or being occupied in the field. That is, as one considers a more active Federal role in dealing with employment of engineers—if you will, a sort of assured employment function—you also have to implicitly expect a Federal role in dealing with the total numbers that are going to be permitted in that field. This would be a type of valving function which would turn on a certain flow of engineers through the system. This is something that the Federal government has not done; it has acted to provide a pull, but it has never pushed back on the field and said you cannot enter. This is one of the problems which I think one faces when you consider a long term strategy for dealing with science and engineering manpower.

The Federal government also doesn't get involved with some of the other concerns that were mentioned earlier in the Conference—setting salaries, for example. Perhaps this occurs indirectly because of the entry of new graduates into the government employees classified grade structure, but certainly not in any direct way. Nor does the government become involved with things like fringe benefits or other aspects of the emoluments that engineers receive.

We have not been engaged in what has been termed a "technological WPA"—that would be a sort of make-work program for engineering talents. Again, this statement has to be considered in perspective. The public employment activities of the Department of Labor tend to have this function in society. There are people who are needed on the state and local government scene, and there is a prospect for greater utilization of scientists or engineers, and I think there is an attractive prospect in this area. But on the whole, technological WPA is not one of those policy options which government tends to consider.

We also do not get involved with setting professional standards and I think here is a question where the concerns of the IEEE and other organizations would have to dictate the approach that was taken in the community. I doubt whether the Federal government would see this as a role that government should play.

And so the range of policy responses in dealing with the problems that engineers see today and have experienced over the past decade or so, is limited by this class of actions that I have just described. It's mostly oriented to providing a pull on the system; it has not been very effective in dealing with the problems of oversupply, under- or unemployment.

Now what can we expect from the Federal Government in responding to the current situation and perhaps in dealing with some of the long range problems that were highlighted by Myron Tribus and others? Well, in part, what you may expect will relate to the kind of institutional structures that exist for dealing with this problem. So I would like to review for you, very briefly, the current situation with respect to the science advisor to the President and the new reorganization of the National Science Foundation.

First, the science advisory apparatus as it applies to the President and his office. As you know, beginning in 1957 and extending through the reorganization in January of 1973, there was a structure which was more or less along the following lines:

The Science Adviser reported directly to the President and was responsible for reviewing and advising on a wide range of scientific and technological programs of the Federal government. This individual wore several hats, however. He was Director of the Office of Science & Technology, an office established to provide staff assistance in carrying out his role. There was also an interagency activity called the Federal Council for Science and Technology and he also acted as Chairman of it. The idea behind the Federal Council was to provide a coordination

mechanism, a communication mechanism among the various Federal agencies with major science and technology interests. Its membership includes the Administrator of NASA, the Assistant Secretary of Commerce for Science & Technology, Assistant Secretaries of the major departments with research and development activities, the new head of ERDA, and so forth.

Finally, there was one additional element in this structure—the President's Science Advisory Committee, which was also chaired traditionally by the Science Adviser. The PSAC was a group of mostly non-governmental people who were appointed as Presidential Consultants, and who became involved with a wide range of issues dealing with everything from military R&D matters to science manpower. When the reorganization that was announced in January 1973 took place, the PSAC and OST were abolished, and the role of science adviser was assigned to Dr. Stever who then served simultaneously as Director of NSF, Science Adviser and also Chairman of the Federal Council for Science and Technology. For the past 2 years this is the organization which has existed in the Executive Branch dealing with general science policy matters. Within the NSF several staff organizations were established to assist Dr. Stever in carrying out his Science Adviser role. I am the Director of one of those staff organizations—the Science and Technology Policy Office.

Realizing that these multiple functions are a rather excessive burden for a director of an operating agency—an agency, by the way, which has been growing at a regular and I think a rather impressive rate over the past years—and the need for a closer tie to the internal organization of the White House and the President's Staff, President Ford has recently announced his intention to modify this organization and reestablish some of the elements that were previously incorporated in the old science and technology policy structure in the White House.

The new structure which has been proposed by the President has a Science and Technology Advisor who would serve simultaneously as the Chairman of the Federal Council for Science and Technology. He will have an Office of Science and Technology Policy, which will provide the staff to assist him in carrying out his role as the Science and Technology Advisor to the President. The incorporation of the word "technology" in the adviser's title is intended, at least in planning at this stage, to have a great deal of significance because it is generally recognized that one of the major areas of concern for the United States in future years is perhaps less a question of science and more a question of national technological policies. And so with this understanding, the words, science *and technology*, while they flow very easily, really are intended to be much more significant than simply because they fit very nicely together. They are *really* intended to imply a much stronger focus on technological matters.

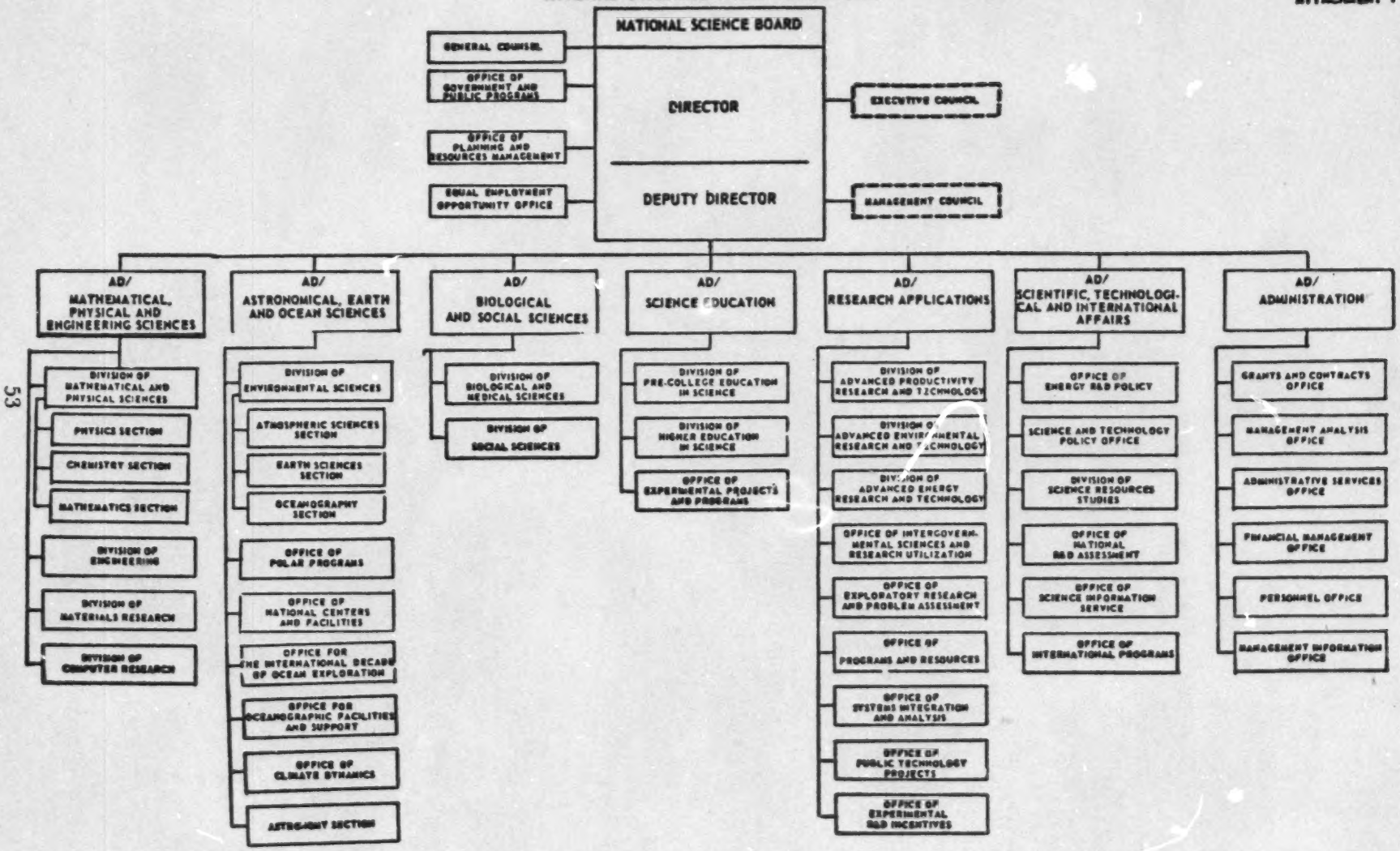
Where does this proposed reorganization stand right now? It is in the form of a proposal submitted to the Congress by the President. We have had a set of hearings before the House Science & Technology Committee, which has jurisdiction in this particular matter. Those hearings have been completed and there is a report of the hearings being assembled. It is possible the new arrangement could be established by about mid-October. Dr. Stever, therefore, will be serving as the Science Adviser into the fiscal '77 budget season and my staff will continue to support that role in the coming months. And we intend to make a rather smooth transition to the new organization.

I have described what the President has proposed. That's not, of course, what was introduced in the House in the form of HR. 4461, which deals with a much broader range of issues. It includes a statement of national science and technology policy and, while it is a very general statement, it does represent the desire of the Congress to begin to deal with questions of establishing longer range policy in this area. Such a policy statement has for the most part been avoided by the previous Science Advisers and by the Congress as well. There is also another provision in HR. 4461 that deals with the establishment of a new department. It's an unusual department, however—it incorporates some of the major civil R&D performing entities in government—the National Bureau of Standards, the NSF, ERDA, NOAA, NASA, and a new organization called a Science and Technology Information Utilization Corporation which is intended to provide a systematic dissemination tool for science information from government to the private sector and state and local governments. These features were incorporated in the original House bill and they are going to have to be disposed of before final House action can be expected. The Senate has not yet acted so we expect it's going to be mid-Fall before we have legislation in place and perhaps a month later before an individual is appointed as Science Adviser and the new, strengthened organization with good ties with the Executive Branch is established.

In the past two years, the National Science Foundation has been playing a dual role and there have been some complicating factors because of it. There also has been a desire for some time on the part of Dr. Stever to reorient the internal structure of the NSF. With the President's announced decision and with the way reasonably clear to a new structure, the new organization of the NSF was announced last Thursday. (You should have a copy of the new organization chart. It's pretty busy, but I think you will find it of interest if you spend a little time studying it.) The organization is particularly significant because of one very important aspect, and that is the formation of an entirely new directorate called Scientific, Technological, and International Affairs (STIA for short). This directorate incorporates three policy-oriented offices, the Office of Energy R&D Policy, the Science & Technology Policy office and the Office of National R&D Assessment. These offices have, in the past, been concerned with science and technological policy matters. In addition, however, you will notice that Science Resources Services is now incorporated into this directorate as well as the Science

NATIONAL SCIENCE FOUNDATION
INTERIM ORGANIZATION STRUCTURE

ATTACHMENT 1


NATIONAL SCIENCE BOARD
GENERAL COUNSEL
OFFICE OF GOVERNMENT AND PUBLIC PROGRAMS
OFFICE OF PLANNING AND RESOURCES MANAGEMENT
EQUAL EMPLOYMENT OPPORTUNITY OFFICE
DIRECTOR
DEPUTY DIRECTOR
EXECUTIVE COUNCIL
MANAGEMENT COUNCIL
AD/ MATHEMATICAL, PHYSICAL AND ENGINEERING SCIENCES
DIVISION OF MATHEMATICAL AND PHYSICAL SCIENCES
PHYSICS SECTION
CHEMISTRY SECTION
MATHEMATICS SECTION
DIVISION OF ENGINEERING
DIVISION OF MATERIALS RESEARCH
DIVISION OF COMPUTER RESEARCH
AD/ ASTRONOMICAL, EARTH AND OCEAN SCIENCES
DIVISION OF ENVIRONMENTAL SCIENCES
ATMOSPHERIC SCIENCES SECTION
EARTH SCIENCES SECTION
OCEANOGRAPHY SECTION
OFFICE OF POLAR PROGRAMS
OFFICE OF NATIONAL CENTERS AND FACILITIES
OFFICE FOR THE INTERNATIONAL DECADE OF OCEAN EXPLORATION
OFFICE FOR OCEANOGRAPHIC FACILITIES AND SUPPORT
OFFICE OF CLIMATE DYNAMICS
ASTRONOMY SECTION
AD/ BIOLOGICAL AND SOCIAL SCIENCES
DIVISION OF BIOLOGICAL AND MEDICAL SCIENCES
DIVISION OF SOCIAL SCIENCES
AD/ SCIENCE EDUCATION
DIVISION OF PRE-COLLEGE EDUCATION IN SCIENCE
DIVISION OF HIGHER EDUCATION IN SCIENCE
OFFICE OF EXPERIMENTAL PROJECTS AND PROGRAMS
AD/ RESEARCH APPLICATIONS
DIVISION OF ADVANCED PRODUCTIVITY RESEARCH AND TECHNOLOGY
DIVISION OF ADVANCED ENVIRONMENTAL RESEARCH AND TECHNOLOGY
DIVISION OF ADVANCED ENERGY RESEARCH AND TECHNOLOGY
OFFICE OF INTERGOVERNMENTAL SCIENCES AND RESEARCH UTILIZATION
OFFICE OF EXPLORATORY RESEARCH AND PROBLEM ASSESSMENT
OFFICE OF PROGRAMS AND RESOURCES
OFFICE OF SYSTEMS INTEGRATION AND ANALYSIS
OFFICE OF PUBLIC TECHNOLOGY PROJECTS
OFFICE OF EXPERIMENTAL R&D INCENTIVES
AD/ SCIENTIFIC, TECHNOLOGICAL AND INTERNATIONAL AFFAIRS
OFFICE OF ENERGY R&D POLICY
SCIENCE AND TECHNOLOGY POLICY OFFICE
DIVISION OF SCIENCE RESOURCES STUDIES
OFFICE OF NATIONAL R&D ASSESSMENT
OFFICE OF SCIENCE INFORMATION SERVICE
OFFICE OF INTERNATIONAL PROGRAMS
AD/ ADMINISTRATION
GRANTS AND CONTRACTS OFFICE
MANAGEMENT ANALYSIS OFFICE
ADMINISTRATIVE SERVICES OFFICE
FINANCIAL MANAGEMENT OFFICE
PERSONNEL OFFICE
MANAGEMENT INFORMATION OFFICE

Information Service and the Office of International Programs. These divisions have been taken out of directorates that existed in the former structure. The other major feature of this reorganized structure is that the research directorate, which was becoming an extremely large organization dealing with a very sizable proportion of the NSF budget, is now amalgamated with the former directorate for national and international programs to form three major research directorates. They are: mathematical, physical, and engineering sciences (one directorate); astronomical, earth and ocean sciences (in another directorate) and the biological and social sciences. Science education remains about the same with the exception that Sciences Resources is moved, and the RANN program is the same as in the previous NSF organization.

The intent is to provide better communication within the top management structure of the NSF between the various disciplines that are identified within these research directorates, and thereby improve the visibility of the activities that are ongoing within that directorate and give them a greater voice, and not dilute them, within a very much larger structure, in which the communication channels may have been somewhat strained and overloaded at times. The new structure is intended to provide a much more effective communication tool, a much more sensitive one for dealing with research issues. You will notice also that the national centers, the institutional support that is required in connection with many of the research activities, is combined with the research in those areas, for example, the program for the International Decade for Ocean Exploration—is being brought together with Ocean Science Support, and the National Centers for Astronomy brought together with the support for astronomical research.

But the important innovation, in terms of science manpower is the STIA. It is my expectation, and in fact will be my recommendation, that the STIA become the focal point for science and engineering manpower questions within the Federal government, particularly from the standpoint of the user community. Within the various elements that are being brought together in the new organization there is already a significant capability for analysis and data gathering that would be coupled closely with the new White House science office. In this way STIA could serve as the focal point for manpower questions that was recommended in the EJC manpower policy statement.

What can NSF do about some of the concerns of Engineers as they have been stated at this meeting? Well, probably less than you might hope, but more than you might expect, based upon past experience. If we are optimistic, with increased attention that can be brought to bear by knowledgeable people in STIA who have spent some time gathering their facts and putting them together in a rather coherent way we will be able to elicit some action on the part of the Federal establishment.

There are three major hurdles one has to overcome in dealing with a program that might actually accomplish a new objective or new purpose. The first hurdle is agency management. Within this agency management hurdle there are perhaps three major aspects that have to be considered. First of all, I would classify the principal one as inertia. The Federal government is generally an area of zero acceleration because the major propensity is for things that are not moving to stay at rest and for things that are moving to continue to move. So programs which have been established tend to continue long after their need has passed from the scene and change and quick response to new needs tends to be a most difficult thing to achieve. So you have this sort of built-in inertia in the system. Second, you have what I would call timidity. There are agency administrators and program managers and assistant directors that are simply afraid of the exposure or the exposed position they will put themselves in if they move aggressively to promote a new program—something that changes direction or in other words, introduces accelerations in the system. Finally, there is a lack of conviction that resides within many administrators. They listen to the voices of their constituency and it may be that they hear about unemployment, they may hear about poor working conditions, they may hear about the need for retraining; but they really don't quite believe it. They are not quite convinced. And so there is this hurdle that must be overcome—you've go to present a sufficiently convincing case to the agency administrators to stimulate the combination of actions that have to take place at the agency level before you can begin to set programs in motion.

The second major hurdle is OMB. OMB is the whipping boy—has been for quite some time—but they probably deserve the reputation they have. However, to be really quite fair, the OMB in my experience has included the most dedicated and I would think high quality civil servants that you will find in Washington. OMB staff are quite serious about their job, they are serious about their responsibility in guarding the President's interest, and if proposals are killed in OMB they are usually killed for very good reasons. What are some of those reasons? Well, again, a principal factor is the failure to make the case. If an agency comes into the OMB with a poorly planned, a poorly justified, and sloppily put together program as part of the normal package of budgetary materials, the OMB staff normally will counter with some penetrating and very leading questions. And what happens? The agency begins to falter; they don't come up with the right kind of answers; they haven't asked themselves the right tough questions. And so the failure to make the case is probably the most critical aspect of the OMB-agency interaction and it creates one of the most significant aspects of the OMB hurdle that has to be overcome.

The second aspect is political palatability. In other words, the OMB in addition to being a guardian of the budgetary gates, also is a political animal and has to be sensitive to the political climate. It's within this combination, then, of budget and political viability that many

programs, even reasonably well-justified programs, fall a cropper; they simply do not have the political support within the Congress, within the public generally—they may be too far out. The lesson for this audience is that you should build a political constituency simultaneously so that when the program proposal arrives in the OMB, and it is adequately justified and supported, it also has a political receptiveness built in.

The final aspect of the hurdle that is encountered within the OMB has to deal with bureaucratic rivalries. In other words, institutional problems for which the clear authority to proceed or to carry out a program is not yet established. It may be that there are multiple agency responsibilities and no one wants to give up his prospect of participating in the program. This may require aggressive action on the part of someone in an advisory capacity close to the President in overcoming the kind of bureaucratic rivalries that take place within the Federal establishment. It may require assignment of lead agency responsibility, where an agency is told to get on with a job, and coordinate with the other agencies that have a shared responsibility, but with clear responsibility to proceed in a single management structure.

The last set of hurdles is the Congress. You know that Congress is more and more a partner in government in dealing with issues and getting programs off the ground. But you also know there are some significant barriers that are present in the Congress. First there is lack of conviction that there is a need. Here there is an important role for the societies of the EJC in presenting a clear, lucid, and convincing case for action in the manpower area. There are some guidelines that should help to improve this process. First, try to relate the issue to a larger context. Why is the problem important? What are the really important fundamental implications of the problem? Again, it may be that action to address the problem is politically unpopular, and this is another part of the hurdle that Congress presents. Political unpopularity may be related to an aspect of the manpower issue that has been talked about here earlier, and that is, "How can you generate political support for, let's say, 36,000 unemployed engineers when there are seven million people unemployed in the larger work force? How do you build some sort of constituency and willingness in Congress to be able to act under those circumstances?" This is a difficult challenge. At a meeting with a group of science societies recently, Professor Eli Ginzberg, who is Chairman of the National Commission for Manpower Policy and has been involved with manpower questions generally for many, many years, when speaking to this issue, led off the discussion by asking "Why should we be treating you specially? You are in fact a very privileged group already in society. You had a very special educational preparation; you have a rather unique and rewarding opportunity that is available to you. Why should we, looking at it from the broader aspects of manpower problems in the U.S., why should we give this particular small group a special consideration.

Why indeed? That's a question you have to answer, and I think there are some bases for an answer, but this question should be addressed; you can't really just sweep it aside. In order to do this effectively you must build a constituency or broadly based communication channel to this political structure. Let me illustrate how a small group using their particular point of view and their particular access have demonstrated how one can gain access to the political process even though they are a small number. The group is the American Medical Association. At a meeting of science societies, we asked the AMA to describe how they dealt with Congress, and how they communicated and presented their point of view. The AMA representative said, "Well, our Congressional lobbying takes place of course in a fairly systematic way. We have one rather unique approach that we take and that is, we have the personal physician of every Congressman identified as part of our lobbying team." Well, he was only partially being facetious in this; in general they do have the personal physicians of every Congressman represented in the AMA and they do use that as a device for communicating with the lawmakers. Now that's clout, and I think what engineering societies should look at is the way in which a smaller group within society can have a voice that is perhaps important and visible enough to cause the Congress to take effective action.

Let me conclude my remarks by touching upon some of the rather major Federal trends that I see developing in Washington because I think they are important to some of the aspects of the manpower problem. First of all, manpower training. The general philosophy that has been developing calls for selective Federal support for college and postgraduate training in disciplines that represent scarcities, or special needs, rather than large scale institutional support of the training of scientific and technical personnel. An example is the health manpower area. There is a requirement now which puts the Secretary of HEW in the position of determining those areas in which there are going to be shortages and determining what sort of training support is appropriate to those shortages. I believe you are going to find that training funded by NSF, which includes special emphasis on energy-related programs, will be also extended into other areas where there is a specific felt need. However, the planning base for doing projections and predictions of where potential shortages might be occurring is going to have to be improved significantly if this philosophy is going to have any meaning and any relevance at all. At present, this is an extremely weak base, and I would view that as a particularly critical area.

Also in the manpower area there is growing concern about the financial plight of the colleges. Someone at this conference mentioned that they thought the future would bring complete Federal subsidization of college training. I don't see that occurring, but I do see a much stronger Federal role. And certainly there is going to be a great deal of concern and sensitivity about what happens to the financial situation for colleges. There is also going to be, and already is, a concern about stagnation in the professorial ranks in colleges. There are some projections that

the number of openings for new professors over the next ten years is about 30,000, as compared with 300,000 in the last decade, or a reduction to 10% of the previous inflow of new people. If that indeed is the case, it will cause a rather skewed age distribution, where the average age in the professorial ranks begins to increase by 11 months every year. That has some very significant implications for the whole college picture, particularly the introduction of new people and the opportunities for those new people.

NSF will continue to develop and pursue curriculum development programs. You will find that the reorganization within NSF is not intended to really change or reduce the role of NSF in dealing with college curriculum development and support. But, the recent interactions between the Congress and NSF on the curriculum development activities of the Foundation have caused a spotlight to be focused on this program. So these programs are going to have to be defended much more strongly and I think they are going to be looked at much more closely in Congress.

Productivity, a question which has been raised many times here, is going to be one of the major new focal points for policy analysis. A major element will be the concern for a better approach to the technological policies and particularly to the health of the industrial sector in the United States, and the way in which Federal R&D can be used productively in dealing with this problem. This is a very important question, but it must be handled very carefully. It's a question, however, that will be very high on the agenda for the new White House science office.

In addition, the level of funding for R&D programs is going to be a continuing emphasis for this new office. I would expect that we will see continued real growth in future fiscal years. This year, the Federal government is projected to spend 22.6 billion dollars, an increase of over 14% over last year. The increase in the last two years in Federal R&D support has been something in excess of 4 billion dollars, and if you translate this increase at the rate that Prof. Landis suggested, of about $50,000 per engineer, neglecting inflationary effects, there would be 80,000 potential new jobs available because of R&D support by the Federal government over these past two years. Even with inflation, this increase should have a very significant effect in turning around the current state of affairs for engineering employment in my view.

The Federal regulatory role will continue to be under some very close scrutiny in the months ahead.

Finally, the top level attention that's indicated by the meeting the Vice President is having tomorrow with S&T leaders, and the interest that he has shown in science and technology, will bode for better communication between the interested user community and the top level in the Administration.

Let me close with a story that's told about Winston Churchill during the war years when he was busy holding together the Empire under the German onslaught. One day, despite his busy calendar, he was visited by a group of Temperance Society representatives. The leader of the group was berating the Prime Minister for his well-known habits of drinking and smoking. By way of illustration of the seriousness of her charge about the example he was setting for the young people in the country at the time, the lady who was the leader said, "Mr. Prime Minister, if all the alcohol you managed to drink in your life was poured into this office it would come up to here." Whereupon the Prime Minister raised up, looked at the imaginary mark on the wall, glanced at the very high ceiling of his office, and said, "So little accomplished, so much yet to do!"

Remarks at the
Engineering Foundation Conference,
Henniker, N.H.
Engineering Manpower:
A National Problem or a
National Resource?
by Daniel Hecker July 18, 1975

The Bureau of Labor Statistics publishes the Occupational Outlook Handbook, primarily for use in vocational guidance in high schools. It includes information on job outlook for about 850 occupations, including engineering. The Bureau also publishes information on occupational training needs, for use in education planning; in this work, projections of manpower requirements are presented in detail, along with supply, where possible. Projections are made for about 10 years in the future.

The Bureau estimates that about 1.1 million engineers were employed in 1974. This estimate is based on surveys of employers, rather than self reporting, as in the Census. Industry employment is based on BLS surveys, college and university employment on National Science Foundation surveys, and Federal government employment on U.S. Civil Service Commission data. An engineer, for purposes of these surveys, is a person doing engineering work at a level requiring knowledge equivalent to that obtained in a 4 year engineering curriculum. This definition therefore includes upgraded technicians and those with degrees in related fields working in engineering; it excludes engineering degree holders not currently employed as engineers.

During the decade of the 1960's, engineering employment grew faster than the average for all occupations primarily because engineers were concentrated in industries that were growing faster than the average, rather than because engineers increased as a proportion of employment in individual industries. In developing the projections, the trends in the proportions were continued for most industries but some adjustments were made for anticipated changes in product mix, R&D expenditures, and the energy situation.

Requirements for 1985 are projected at about 1.5 million, a 36 percent increase from 1974 to 1985. This is somewhat faster than the growth expected for the economy as a whole. The projections indicate an annual average of about 76,000 new entrants will be needed through 1985. About 36,000 openings each year between 1974-1985 are expected to result from growth, and about 40,000 openings from deaths, retirements, and transfers out of the occupation. Death and retirement rates are based on the age distribution for engineers in the 1970 Census. Transfer rates are based on fairly weak data, however, the Bureau is in the process of developing some more reliable figures.

Looking at supply, an annual average of 38,000 new engineering graduates of U.S. univrsities (including those with degrees in engineering technology) are expected to enter engineering through 1985. This number is based on Office of Education projections, which indicate an average of 44,000 B.S. degrees a year will be granted in engineering over the period, and an entry rate of about 85 percent. This rate was developed from follow-up studies of college graduates. Roughly half of the 76,000 openings, therefore are expected to be filled from this source. This is about the same proportion as during the 1960's.

Other entrants are calculated to fill openings in the same proportion as they did in the 1960's. Ten percent of openings during the 60's were filled by recent college graduates with degrees in fields other than engineering – mostly mathematics, geology, and physics degree holders – based on the same follow-up study of college graduates. This would be about 7,000 entrants a year over the next decade from this source.

Another 10 percent of openings during the 1960's were filled by immigrants, based on data on immigrants who reported themselves as engineers. This would be about 7,000 entrants a year from this source. Current immigration rates are lower than this, however. Thirty percent of openings were filled by other entrants, including upgraded technicians, as well as persons with college degrees transferring from other occupations (some who had engineering degrees). Continuation of this rate would indicate about 23,000 entrants a year would come from this source.

All these data on supply total to 75,000 a year, versus requirements of 76,000 a year. Even though these figures indicate a rough balance of supply and requirements, at least some part of the supply will be made up of people—what has been described as other entrants above—who will enter engineering because not enough engineering graduates will be available to fill all openings. Clearly, the economy should be able to effectively absorb more new engineering graduates than are projected to be graduated.

The question arises whether there will be a sufficient number of people available from these other sources of engineering manpower in the future to meet the need, and how will continued reliance on these sources affect the quality of the engineering work force.

I expect that a sufficient number of people from these sources will be available over the next decade, given the Office of Education's projections of degrees in related fields, and data on the number of engineering technicians being trained. Looking at the qualifications of the people from these sources who entered during the 1960's, about 90% of the immigrants reporting themselves as engineers also reported holding at least a bachelor's degree. A great many of them were probably well qualified to do engineering work. Many of the recent college graduates with degrees in related fields, some of whom also had some courses in engineering, also were likely well qualified. As for the upgraded technicians and transfers in, we don't know much about them, although I suspect many of them had developed valuable specialized skills on the job or employers would not have hired them.

Also, we can look at the experience of the 1960's, when

only half of all openings were filled by graduates of U.S. engineering schools, to see how well the engineering workforce performed. The evidence is mixed, and inconclusive. There is some evidence that productivity increases in the non-aerospace sectors of the economy were limited by shortages of technical manpower, caused in part by the aerospace industry's absorption of a large part of the engineering workforce. Other observers, however, have indicated that overall, we managed fairly well.

I would also like to mention the Bureau's impact studies, which could be quite useful in developing a national technology policy. They permit us to look at the employment effects of changes in assumptions in our model. A change in the assumed output of a given product, for example petroleum, can be translated into changes in industry employment in petroleum refining, petroleum extraction, etc. and thus to changes in engineering requirements.

We recently completed a study on the impact of Federal pollution control expenditures. Their employment generating potential can be compared to that of other programs, for example defense or NASA expenditures. Federal funds for pollution control R&D generated 8,000 jobs per billion dollars in 1970, roughly the same number as generated by a billion dollars of NASA expenditures, while grants for construction of waste water treatment plants generated about 2,500 engineering jobs per billion dollars, about the same as a billion dollars on defense. Of course the pollution control program is much smaller. Total pollution control expenditures are about $4 billion now, versus $80-90 billion for defense and $3 billion for NASA.

Supplementary Notes for Presentation
by Israel Katz
Northeastern University, Boston, Mass.

ENGINEERING MANPOWER AND A NATIONAL EDUCATION POLICY

Engineering Foundation Conference — July 14-19, 1975
Panel on Continuing Education of Engineers

LEARNING-ON-THE-JOB

1. Because engineers spend most of their alert and active time on their jobs, a prime objective of CES should be to help make each engineer's job an important learning activity. Learning on-the-job may be stimulated several ways, but CES, focused on the interactive solving of difficult problems confronting each engineer on the job, not only fosters learning on the job as part of an engineer's professional practice, but also encourages engineers to teach their colleagues and support personnel how to learn on the job in the processes of transferring and utilizing technology in their own work. For professionals, teaching others is a key to their own learning. It is the engineer's and employer's joint responsibility to make the engineer's job a problem-centered adventure.

2. Most professionals learn anywhere between zero to 100% or more of what they need to know to keep doing what they are doing by doing it. Because the scientific and technological targets of their work are generally changing at unprecedented rates, engineers who learn less than 100% of what they need to know to keep doing what they are doing, are falling behind. Those who learn less than 100% require CES that supplements and further stimulates learning on the job.

3. Engineers who learn much more than what they need to know to keep doing what they are doing, and are able to serve as resource persons in teaching/learning processes with others, should be enlisted to participate in CES as teachers. They in turn will find that they learn as much or more from their CES students than the students learn from them and thereby enhance their own competences and reputations all the more.

4. Feedback from engineers during their interactive CES courses about applications of new knowledge to their jobs, stimulates constructive criticism and suggestions from the class useful in practical problem solving. The process, however, also transfers ideas to all class participants useful in solving their own job-related problems.

LEARNING READINESS OF THE PARTICIPANT

1. Has a stable job or valid promise for obtaining one.
2. Free of inordinate personal, family, community and professional concerns or commitments.
3. Free of destructive involvement with politics on the job.
4. Prepared in terms of education and experiences to benefit from participation in a teaching/learning process.
5. Uninhibited by personal and professional factors to participate in an interactive teaching/learning process that may become heated and require a thick skin in defending one's ideas and contributions.
6. Motivated to participate in the give-and-take of interactive problem solving, which requires a desire to share unique experiences and expertise with others, but without compromising proprietary information or security.

KNOWLEDGE CONTENT THAT SUPPLEMENTS AND STIMULATES LEARNING ON THE JOB

1. Courses, seminars and workshops related directly to the participants' professional responsibilities in areas or at levels that deal with new knowledge that is normally too difficult or time consuming for an individual to acquire alone, or is so peripherally related to an individual's job, yet impacts sufficiently upon the individual's work, that formal coursework is indicated.

2. CES should focus on difficult problems confronting individuals on their jobs, require all participants to apply pertinent new knowledge acquired in a CES program to their jobs, and provide feedback from such knowledge applications to their classes for analysis, discussion, suggestions, and the continued iterative applications of new knowledge to each participant's job until each problem is solved or better understood.

3. CES should encourage technology transfer and utilization through interactive problem solving based on the iterative applications of new knowledge to their jobs and feedback for subsequent analysis of progress. In doing so, CES would stimulate the participants to learn on the job, provide and discuss feedback, take criticism and suggestions in stride, and help their own colleagues and support personnel at work to benefit from learning on the job.

RESPONSIVE EDUCATIONAL ORGANIZATIONS

1. Stimulated by fast moving scientific and technological targets, responsive educational organizations take risks in developing and offering educational programs in which the new knowledge content is advanced, often speculative, frequently not yet committed to print, but sufficiently provocative and pragmatic to be of interest to a sufficient number of applied scientists and engineers so as to warrant an information exchange amongst them. The risks are in terms of investments of staff effort and funds to search out resource people in the field, enlist their support to outline and develop a program, commit physical facilities, and promote the offering. Such programs, almost invariably, fail to pay their own way, but eventually become more than self-supporting.

2. Search for and organize the required teaching staff from amongst persons in academia and professional practice who are sufficiently knowledgeable in the field, or in related peripheral areas, to serve as resource persons to professionals earning their livelihoods in the

same field. Such faculty members must be capable of planning programs as well as stimulating and leading heated discussions, critiques and interactive problem solving sessions amongst informed professionals and be sufficiently knowledgeable to help such groups over difficult or controversial points as they arise and seek expert assistance from other resource persons as required.

3. Survey their own community needs for new technology and determine the probable market for educational programs to fulfill such needs.

4. Assess technology and research emergent technologies with a view towards preparing educational programs conducive to technology transfer and utilization consistent with societal needs and national priorities, but with a special focus on their own community interests and practical extrapolations of such interests consistent with anticipated means of the community to excel in reducing R&D to marketable products and services.

5. Seek out participants who can benefit professionally from CES in terms of enhanced performance on their jobs, technology utilization in their companies' products and services, transfer technology to colleagues and support personnel, as well as share with other participants their unique experiences and expertise.

6. Provide interactive teaching/learning opportunities for participants that draw upon their unique experiences and expertise, thereby achieving an important form of technology transfer.

7. Encourage the participation of their own faculty members in continuing education, either as resource persons or students, and thereby provide means for transferring knowledge from academia to the professional fields of practice; but more importantly, facilitate the injection of new knowledge from professional practice into academia.

SATISFIED AND SUPPORTIVE CUSTOMERS

1. Employers who are convinced that they are benefiting from support of CES for their employees.

2. Employers willing and able to underwrite out-of-house CES for employees in high-level programs despite operation of an inhouse program. Participants who sense or observe significant personal growth in competence on the job and an ability to transfer knowledge to colleagues, support personnel and their own customers.

3. CES sponsoring public and private agencies who witness an ability of programs to sustain themselves after initial supported implementation.

4. Evidence of sustained technology transfer and utilization by and among CES program participants well after the program has been completed.

5. Voluntary commitment by participants in a lifetime regimen of CES.

CONDITIONS NECESSARY FOR A SUCCESSFUL PROGRAM

1. Learning-ready participants (students)

2. Willing and able instructors (resource people)

3. Motivating factors conducive to student commitment

4. Sponsoring organization and administrators with requisite energy, will and competence to do the work required (Conceive, research, plan, organize, promote and implement programs as well as select and counsel students, maintain records and upgrade the teaching/-learning processes involved)

5. Accurate description of offerings

6. Critical mass of students

7. Innovative educational R&D

8. Course/student match: heterogeneous groups – focused on breadth; homogeneous groups – focused on depth

9. Creative risk taking

10. Emphasis on serving needs of students rather than needs of the faculty or organization

11. Use of the interactive teaching/learning process in the advanced programs

12. Supplementing what students learn on their jobs

13. Stimulating problem solving on the job

14. Sufficient faculty encouragement/participation

15. Utilization of foremost authorities in area who can also teach professionals

16. Enlightened administration and support

17. Fighting resistance and energy-sapping politics

18. Competent crew and "string men" for intensive or multi-instructor programs

19. Prompt thoughtful reaction to student applications, questions, suggestions, criticisms and complaints

WHY DO SO FEW (AS % OF TOTAL) ENGINEERS CONTINUE THEIR EDUCATION?

1. Few truly-valid opportunities offered for meeting deep-felt educational needs

2. Learning on the job seems sufficient to many engineers

3. Feeling that competency or productivity does not really pay off

4. Failure of education to involve them in interactive teaching/learning experiences

5. Universities indifferent to product service (meeting post-experience educational needs of their own graduates for competence retention and growth plus career reorientation.)

6. Universities dodging opportunities to be change agents (by coupling their own students and curricula to societal needs and national priorities – many prefer ivory tower isolation from real-life issues, problems and pragmatic considerations)

7. Engineers turned off by prevailing academic attitudes as to what constitutes quality education – prerequisites, credentials, credits, regular faculty, accredited curricula, exams, preset course sequences, inflexible course content

8. Lack of programs dealing with advanced,

speculative, highly applied and as yet unpublished subject matter

9. Lack of instructor's flexibility to swing with the needs and interests of class. Usually offer off-the-shelf programs such as watered-down graduate and under-graduate courses

10. Dogmatic expostulation of theory known to be out of date, impractical, questionable or wrong

11. Avoidance of real problems of special interest to students on their jobs

12. Undue focus on analysis rather than design synthesis

13. Lack of privacy on academic matters – in the extreme, the flow of classroom or course performance data to employers

14. Tuition refunds tied to grades

EMERGING ROLE IN EDUCATION – UP FOR GRABS

1. Sources of new knowledge – 15% from academia, 85% from professional practice

2. Harvesting, refining, compressing, and transferring new knowledge

3. Utilization of new knowledge – the world of work provides greatest opportunities for technology utilization, transfer and assessment

4. Vulnerability of the universities to replacement by responsive organizations

5. The knowledge injection process – essential conditions

6. What kind of organization will grab and run with the ball?

7. Who will serve the highly-specific, but formal, educational needs of advanced professionals in all fields?

THE FRENCH CONNECTION

1. Is continuing education working in France? Not yet for advanced professionals

2. What are the problems? Faculty and educational institutions uncooperative – ivory tower syndrome, watered-down graduate and under-graduate courses offered

3. Focus on industrial needs, particularly those owned or regulated by the state?

4. Prognosis for the future: Trade associations, engineering societies, large industries, and public utilities will expand offerings (ranging from technician-training to advanced engineering and applied science programs) to their own members and employees, but also on an open-to-public basis.

REMARKS TO THE ENGINEERS JOINT COUNCIL MANPOWER CONFERENCE COMMITTEE

By Warren C. Stoker,
President, Rensselaer Hartford Graduate Center

The pace of change in American society is one of its principal characteristics. This pace seems constantly to be increasing. In industry, high technology-based environments are the scene of almost constant change, environments alter, objectives change. Program requirements shift in focus and emphasis. New research results and feedback from development runs necessitate readjustments in objectives, project design, materials requirements, and scheduling. New knowledge permits new products and processes to be developed and also requires new kinds and levels of human skills.

Those who have been educated most recently are thought to be those who are most likely to have the most recent or current knowledge to tackle new projects. Given the "tough" or "hot" assignments, these engineers have the opportunity to remain current, up-to-date, "on the cutting edge." It is they whose skills growth and professional development constantly recurs. More effective means are needed to maintain currency at reduced cost. Even so, we must recognize that this younger age group represents the minority of professionals in virtually every setting.

The vast majority, those 10, 7, even 5 years from their last formal educational experience, have an equal or greater need for continuing updating and professional growth. Those older (20-25 years out of the university) and in mid-career have the greatest need for continuing education to expand their capabilities to meet the broadened areas and increased levels of job responsibility.

Despite the long period this problem has existed and the growing recognition of this problem, i.e., the need for personal and professional growth of the working professional engineer on a regular systematic basis, the problem still persists. Thus, in responding to this problem and need, we are concerned with the continuing education of both the newly graduated entrant into the ranks of working professional engineers and the older professional throughout the later phases of a working career.

Traditionally, the initiative and responsibility for meeting these educational needs has been centered in the faculty of educational institutions. However, experience in recent years, particularly within the larger industrial corporations, has indicated that the academic response is often too slow or remote to provide the response necessary to adequately serve either the interests of the corporation or the professional individual. In certain cases large educational programs, totally incorporated within industry, have been established. This practice may not make the best use of available educational resources, and being focussed specifically on a single firm may not be in the best public interest, nor serve the professional individual in the most flexible manner. Nevertheless, there is a place for industry initiative and assumption of responsibility if real needs are to be met. The role of the educational institution can be that of a purveyor of high quality education in direct response to, but in collaboration with, industry.

What has most characterized continuing education programs has been their lack of continuity – they continue for the institution but they do not continue for the learner. For the learner, they are intermittent, episodic, occasional, ad hoc, and largely unsystematic shots at one time objectives. These programs are usually tailored for large groups or classes of learners whose needs as individuals are not differentiated.

During the past ten to fifteen years, there has been developing within academic institutions a concern that there be a more relevant response to national needs. This is evidenced by the orientation of research to problems of more practical relevance, by the creation of special institutions dedicating their programs in research and education to the meeting of these national needs, and to very specific studies to more sharply identify these needs. In many cases the areas of concern are primarily those in the broadcast public interest. But also there is an awareness that it is in the interest of the public for the individual to have an education which is most relevant to his career and professional development needs. In such cases the educational institutions are finding that that there must be a closer tie with business, industry, and public administration if the relevant education is to be provided. Such ties represent an unfamiliar association but are being increasingly explored and established.

The challenge is really to make learning revitalization and the growth of skills a continuing process, with learning opportunities available that are responsive both to the corporate requirements for skills development and the professional growth requirements of each individual engineer.

In connection with an institutional planning effort started two years ago, The Hartford Graduate Center has been re-examining its purposes, challenging its own assumptions and pre-suppositions underlying its program, and planning a program responsive to change.

Since the basic mission of the institution is meeting the educational need of working professionals – e.g., professional development, continuing education – an academic planning study aimed at reviewing and analyzing continuing education activities on a national and international basis was undertaken with the aid of funding from the Dana Foundation and The Hartford Foundation for Public Giving and United Technologies Corporation.

Our planning, research and analysis activities, that have been carried on these past eighteen months, have resulted in the development of findings and conclusions regarding continuing education of the working professional. These are based on extensive review of the activities pertaining to continuing education, both nationally and internationally. This includes an assessment of programs such as the Colorado State University SURGE program, the University of Wisconsin Professional Development Degree program, and the British

Open University program. Also included, in addition to the above, was a review of interaction between industry and academc institutions such as Stanford University, Rochester Institute of Technology, and Southern Methodist University. Further, a review of the state-of-the-art in educational technology was included covering production and delivery of learning packages and the application of computer assisted instruction, television, video-cassettes, audio-cassettes, correspondence courses and self-paced instructional packages. Site visits were made throughout the country to view facilities, interview individuals and discuss programs and needs with the academic and industrial community.

Close interaction has been developed locally to identify and understand the needs of our local corporate partners who are sponsors of graduate education for their employees. Finally, we conducted a workshop with continuing education experts that produced extensive input to the problems and needs for continuing education of the working professional. Information from all of the above activities and sources was analyzed to produce the following summary findings and conclusions:

1. The concept of a continuing assessment of learning needs (skills needs) and designing learning programs responsive to them is foreign to all but the most sophisticated employers.

2. There is a general feeling, in the industries we are working with, that advanced training and professional development carried on by supporting candidates in degree programs has not served corporate purposes with sufficient precision. Under current economic pressures, budget restrictions are forcing a re-examination of training budgets and tuition reimbursement programs. There is a growing conviction that programs and courses which do not effectively serve corporate purposes, and which cannot be shown to have a direct relationship to productivity, should not be supported. As a consequence, there is decreasing interest in degree programs, and growing interest in education and training efforts which are more individualized, which improve competence and performance on the job, and which can be justified in economic terms as potentially capable of contributing to productivity.

3. These developments regarding degree programs impose on educators a burden and a challenge – the burden of facing up to the growing unacceptability of traditional educational program design, traditional course content, and traditional delivery methods – and the challenge to learn to work with industry to identify needs, to design programs that are more purposefully responsive to the identified needs, to develop course content that will meet learning objectives, and to deliver these programs and content in a variety of ways that are both educationally effective and economically feasible.

4. Historically, joint industry and academic meetings to determine continuing education needs have not been highly successful because they have been occasional and intermittent, and have tended to focus on the problems of the moment as perceived by the industrial representatives.

5. Current academic responses to industry are often self-intitiated and represent faculty opinions on current desires about responding to corporate needs but usually are not accurately responsive. These initiatives are often based on what faculty think industry should have and their perceptions are often wide of reality.

6. The communications gap so often perceived by observers of the educaton-industry scene is merely symptomatic of deeper differences in institutional goals, motivations, incentives, values, attitudes, cultural milieu, and pace. Bridging these more fundamental gaps requires (especially of educators) that they become a living part of the industrial organism they seek to serve. The industrial representatives for the most part have less far to come in reaching understanding and accommodation with faculty since they have been products of the educational experience themselves.

7. Accurate, true identification of industry needs can be accomplished only through close continuing working relationships between the academic community and industry.

8. Careful continuing education needs identification should be an internal and ongoing activity within corporate operations and the process should be assisted as a service by academic representatives.

9. In assessing industry needs, requirements beyond skills acquisition and knowledge input must be met. The characteristics of the learner must be known and the content and delivery mode selected must be compatible both with learning styles and with the nature of the working/learning environment. Principal among these considerations is the attitude and behavior of the employer in generating supportive environments and in developing policies designed to stimulate motivation and encourage self-development in a manner compatible with the pursuit of corporate purposes.

10. Most current programs (with which our current network of advisors and consultants are familiar) appear to be concentrating primarily if not exclusively on content and delivery, and especially on the application of educational technology to the delivery process. These other efforts have, with rare exception, not been as concerned with the human aspects of the learning process – the characteristics of the learner; differing learning styles, skills, and rates of learning; the learning environment; motivation and support; and evaluating the learning effectiveness of alternate modes in different environments.

ENGINEERING MANPOWER AND A NATIONAL EDUCATION POLICY CONTINUING EDUCATION OF ENGINEERS

R. R. O'Neill

Panel discussion presented at the Engineering Foundation Conference on Engineering Manpower, Henniker, New Hampshire, July 17, 1975. **R. R. O'Neill is Dean of the School of Engineering and Applied Science, University of California, Los Angeles.**

SUMMARY: University degree programs prepare individuals for a career in engineering but it is continuing education that determines how effectively and for how long the new engineer will practice engineering. Thus continuing education has a direct impact upon engineering manpower. The continuing education which maintains the effectiveness of the practicing engineers has many dimensions and each is potentially very important; however it is only the more formal types of continuing education which will be considered. Much more serious attention will have to be given to the planning, operation and evaluation of formal continuing education programs. Engineering manpower is an important resource which must be conserved along with other resources. In the long run it is not cheaper to hire new engineers than to train practicing engineers, but in order to overcome the short range advantages of hiring rather than training, a national policy is required.

The majority of new engineers enter the profession of engineering after completing a university degree program. Regarding these programs, there are considerable data published by the Engineering Manpower Commission (EMC) and other organizations, and there are the guidance and monitoring provided by the Engineers' Council for Professional Development (ECPD). However, it is continuing education which determines how effectively and for how long the new engineer will practice. Consequently, continuing education has a major impact on engineering manpower, and yet there is neither the data base nor monitoring which is available for degree programs. Part of the problem is the lack of definition of continuing education. In its broadest context continuing education is professional development and it has many dimensions – many related directly to on-the-job experience. Reading professional journals and technical literature, and developing professional relationships with other engineers are two such important dimensions. However, the following remarks are directed primarily toward the formal, non-degree courses, seminars, institutes and conferences. These activities are not necessarily limited to universities. I include those of the professional societies, employers and also the private organizations which offer proprietary courses.

It is my thesis that we, all of us, must give much more serious attention to the planning, operation and evaluation of these formal continuing education programs. But it has been my experience that we won't unless we have to. Thus there should be some national policy which will provide carrots or sticks. Engineering manpower is one of our Nation's most important resources. Fortunately it's renewable but even so it must be properly used and conserved. In the short run it may appear to be cheaper to hire new engineers rather than retrain those already in the work force; but it cannot be cheaper in the long run when we include the subsidy for education.

It has been said often that the universities have failed to design curricula which are responsive to the real needs of the profession. I won't try to refute this but will respond by noting that we try. Every institution spends countless hours of faculty time planning curricula and courses. Our goal is to get the student with a high school education prepared for entrance into the engineering profession. Furthermore, we don't plan in a vacuum. We do listen to our alumni and to employers. Perhaps the fact that we listen to so many makes it appear that we are responsive to none of the inputs.

On the other hand our continuing education programs are so dominated by a single input – the number of students who sign up for a particular course – that there is no opportunity for real planning. I am certain that those responsible for continuing education programs would be delighted with the opportunity to design programs which would complement and supplement the regular degree programs – in other words provide the missing "ing" courses. Furthermore, given an opportunity, continuing education programmers would also add completely new courses, including some of the "tion" subjects and those directed toward the new engineers. The data distributed by the EMC reveal that the 30 to 40 thousand new engineering degree holders who enter the work force each year are not the same as in the past. The statistics for degrees (B.S., M.S., Ph.D.) and the number of women and minorities graduates show significant changes. But perhaps even more important are the changes which don't show on such tables. Today's graduates have different expectations, values and attitudes toward work. Planning continuing education for this large, heterogeneous group is difficult and requires explicitly stated goals and objectives, but it must be done.

Planning is just the first hurdle. Operating a continuing education program looms next. Each term there is the excitement of a sudden death playoff as our Extension people "open" the courses they have planned. After they have the attention and interest of the prospective students they find that they are at the mercy of many external factors such as the general economic conditions. Our

UCLA Short Course Program suffered significant cutbacks earlier this year because the military changed its travel policy with respect to lead time. Numbers of students are crucial. Although extension pays only ⅓ or even ¼ what the university pays our regular faculty for teaching an equivalent course, their budgets are so tight that they would be hard pressed to carry a course with an enrollment of only 20, whereas we routinely continue a regular upper division course with an enrollment of 8. Not only do the continuing education programmers operate with limited money, they have severe limitations on the time, energy and priority they may demand from their students. Continuing education studies can be quite low on the priority list, especially on the "Do Now" list. A recently published survey[1] of engineers taking University of Wisconsin's Institutes and Short Courses shows that participation in continuing education studies was positively related to salary and job satisfaction. But participation in continuing education studies has elements of deferred gratification. Unfortunately, deferred gratification is not too popular these days.

Planning and operating are difficult. But perhaps the most difficult area is evaluating. It has been my experience that those running continuing education programs do a good job of getting immediate feedback from the participants on their reaction to the program, but I am unaware of any evaluation of the program's contribution to the subsequent output of the participant. I know that we don't really evaluate our degree program in this way but we do have some measures. The job opportunities for our graduates and how well our students do in graduate school tell us something. I suspect that we are inclined to give too much credit to the formal degree programs. As an example, I refer you to the biographies of the participants on this program. With one exception there is nothing about their non-degree education. Intuitively I feel that continuing education is very important to most of us, but I have no way of demonstrating it. Nor would it seem does anyone else. If we would document what we were doing today, it would be easier to do it better tomorrow.

In conclusion I urge this conference to adopt a very strong resolution asking for a national policy calling for the continuing education of engineers. Although I limited my remarks to courses, I would not limit this policy to conventional delivery systems. We desperately need innovation, but we must also make better use of what we have.

[1]John P. Klus and Judy A. Jones, ***Engineers Involved in Continuing Education — A Survey Analysis,*** American Society for Engineering Education, 1975.

CONFERENCE PROGRAM

ENGINEERING MANPOWER — A NATIONAL PROBLEM OR A NATIONAL RESOURCE?

Monday, July 14, 1975
ENGINEERING MANPOWER, WHERE WE ARE TODAY

Session Chairman: Dr. Paul Doigan, General Electric Company

9:00 a.m. *Engineering Manpower At The Crossroads*
Dr. Myron Tribus, Center for Advanced Engineering Study, Massachusetts Institute of Technology

10:00 a.m. *Manpower — Where We Are Today*
Panel Moderator: Mr. Arthur F. Hartford, duPont Company, Chairman, Engineering Manpower Commission

Mr. John D. Alden, Engineering Manpower Commission
Dr. Charles E. Falk, National Science Foundation
Mr. Norman Harvey, Manpower Administration
Mr. Paul J. McGrath, General Motors Corporation

11:30 a.m. *Concerns of Engineers*
Panel Moderator: Mr. Harold E. Roush, RCA

Mr. Harold J. Ammond, Association of Scientists & Professional Engineering Personnel
Mr. Bryce I. MacDonald, Kennecott Copper Corporation
Mrs. Naomi J. McAfee, Westinghouse Electric Corporation
Dr. Roger M. Zimmerman, New Mexico State University

12:30 p.m. Luncheon

RECREATION, READING, DISCUSSION GROUPS

6:00 p.m. Dinner

7:30 p.m. *Workshop Sessions*
Topics to be announced

A. Mr. John D. Alden, Leader
B. Dr. Charles E. Falk, Leader
C. Mr. Norman Harvey, Leader
D. Mr. Paul J. McGrath, Leader
E. Mr. Harold J. Ammond, Leader
F. Mr. Bryce I. MacDonald, Leader
G. Mrs. Naomi J. McAfee, Leader
H. Dr. Roger M. Zimmerman, Leader

9:00 p.m. *Workshop Reports*

Tuesday, July 15, 1975
ENGINEERING MANPOWER AND THE NATIONAL ECONOMY

Session Chairman: Dr. Edward T. Kirkpatrick, Wentworth College of Technology

9:00 a.m. *Economic Growth and Productivity*
Mr. Warren E. Alberts, United Air Lines
President, Engineers Joint Council

10:00 a.m. *Manpower and the National Economy*
Panel Moderator: Dr. Edward T. Kirkpatrick
Dr. Vincent P. Wright, Stone and Webster
Dr. K. Nagaraja Rao, Center for Policy Alternatives, MIT
Dr. Ronald E. Kutscher, Div. of Economic Growth, U.S. Department of Labor

Engineering Manpower and Technology Assessment
Dr. Samuel B. Batdorf, The Aerospace Corporation

11:30 a.m. *The Relation Between the National Economy and Engineering Employment*
Dr. Fred Landis, University of Wisconsin, Milwaukee

12:30 p.m. Luncheon

RECREATION, READING, DISCUSSION GROUPS

6:00 p.m. Dinner

7:30 p.m. *Workshop Sessions*
Topics to be announced

A. Dr. Vincent P. Wright, Leader
B. Dr. K. Nagaraja Rao, Leader
C. Dr. Ronald E. Kutscher, Leader
D. Dr. Edward T. Kirkpatrick, Leader
E. Dr. Fred Landis, Leader
F. Mr. George P. Wood, Leader
G. Dr. Samuel B. Batdorf, Leader

9:00 p.m. *Workshop Reports*

Wednesday, July 16, 1975
ENGINEERING MANPOWER AND GOVERNMENT POLICY

Session Chairman: Mr. David R. Reyes-Guerra, Executive Director, Engineers' Council for Professional Development

9:00 a.m. *National Science and Technology Policy*
Dr. Russell C. Drew, Science and Technology Policy Office, NSF

10:00 a.m. *Minorities and Women in Engineering*
Panel Moderator: Mrs. Jean P. Moore, Board on Engineering Manpower and Education Policy, National Research Council
Mr. Melvin Thompson, Committee on Minorities in Engineering, NRC
Miss Carolyn F. Phillips, Society of Women Engineers
Mr. David R. Reyes-Guerra, Minority Engineering Education Effort, ECPD
Mr. George D. White, U. S. Civil Service Commission

11:30 a.m. *Manpower Policy*
Mr. Robert G. Ainsworth, National Commission for Manpower Policy

12:30 p.m. Luncheon

RECREATION, READING, DISCUSSION GROUPS

6:00 p.m. Dinner

7:30 p.m. *Role of National Data Programs in Establishing Policy*
Mr. Martin M. Frankel, National Center for Education Statistics, HEW
Mr. Norman Seltzer, Manpower Utilization Studies Group, NSF
Mr. Daniel E. Hecker, U. S. Department of Labor

Thursday, July 17, 1975
ENGINEERING MANPOWER AND A NATIONAL EDUCATION POLICY

Session Chairman: Dr. M. E. Van Valkenburg, Chairman, Board on Engineering Manpower and Education Policy, Assembly of Engineering, National Research Council

9:00 a.m. *Continuing Education of Engineers*
Panel Moderator: Dr. Myron Tribus, Massachusetts Institute of Technology
Dr. Peter Chiarulli, Illinois Institute of Technology
Mr. Israel Katz, Northeastern University
Dr. Warren C. Stoker, Rensselaer Polytechnic Institute, Hartford
Dr. Russell R. O'Neill, UCLA
Mr. Donald B. Miller, General Products Division, IBM

10:30 a.m. *Need for a National Technical Manpower Advisory Capability*
An Academic View
Dr. M. E. Van Valkenburg, University of Illinois
An Industrial View
Dr. Dean Gillette, Bell Laboratories

11:30 a.m. *General Discussion on a National Engineering Education Policy*
Moderator: Dr. M. E. Van Valkenburg
Dr. Peter Chiarulli
Mr. Israel Katz
Dr. Warren C. Stoker
Dr. Russell R. O'Neill
Mr. Donald B. Miller
Dr. Myron Tribus
Dr. Dean Gillette

12:30 p.m. Luncheon

RECREATION, READING, DISCUSSION GROUPS

6:00 p.m. Dinner

7:30 p.m. *Conference Integration Workshops*
A. Education—William K. Le Bold and Russell R. O'Neill, Leaders
B. Industry—J. Bruce Martin and James L. D'Acosta, Leaders
C. Government—June S. Chewning and Russell C. Drew, Leaders
D. Professional Societies—Alexander R. Susman and Paul Doll, Leaders

Friday, July 18, 1975
DEVELOPMENT OF RECOMMENDATIONS

Session Chairman: Dr. Paul Doigan, General Electric Company

9:00 a.m. *Reports on Conference Integration Workshops*

10:30 a.m. *Where Do We Go From Here—Recommendations for Action*
Dr. Cornelius Wandmacher, University of Cincinnati

12:00 noon Conference Adjournment

CONFERENCE COMMITTEE

Dr. Paul Doigan, General Electric Company, Chairman
Mr. John D. Alden, Engineering Manpower Commission
Mr. Hans C. Cherney, IBM Corporation
Dr. Charles E. Falk, National Science Foundation
Mr. Arthur Gilmore, Grumman Aerospace Corporation
Dr. Edward T. Kirkpatrick, Wentworth College of Technology
Mrs. Dorothy P. Morris, Victory Engineering Company
Mr. David R. Reyes-Guerra, Engineers' Council for Professional Development
Mr. Harold E. Roush, RCA
Mr. Richard Stone, National Science Foundation
Dr. M. C. Van Valkenburg, University of Illinois

ENGINEERING FOUNDATION CONFERENCE
ENGINEERING MANPOWER—A NATIONAL PROBLEM OR A NATIONAL RESOURCE?

New England College, Henniker, New Hampshire

July 13 — 18, 1975

LIST OF CONFEREES

Dan K. Adamson
Society of Petroleum Engrs.
AIME

Robert S. Ainsworth
National Commission for
Manpower Policy

Warren E. Alberts
United Air Lines

Mr. & Mrs. John D. Alden
Engineers Joint Council

Harold J. Ammond
Association of Scientists
and Professional Engineering
Personnel

Walter F. Arnold
Lawrence Livermore Laboratory

Larry L. Barker
U.S. Energy R&D Adm.

Warren J. Baker
University of Detroit

R.C. Barnes, Jr.
Soil Conservation Service USDA

S.B. Batdorf
Aerospace Corp.

Robert Beckmann
College of Engineering
University of Maryland

Philip P. Bryant
Boston Edison Co.

John R. Canada
N.C. State University

Mr. & Mrs. Clyde S. Carman
University of Arkansas

June S. Chewning
U.S. Energy R&D Adm.

Peter Chiarulli
Illinois Inst. of Technology

L.D. Chipman
Western Electric Co.

James L. D'Acosta
General Electric Co.

Eugene P. Damm, Jr.
IBM Corp.

Vernon O. Davis
Union Carbide Corp.

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National Science Foundation

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College of Engineering
University of Kentucky

Charles E. Falk
National Science Foundation

Martin Frankel
National Center for Education Statistics

Dean Gillette
Bell Laboratories

Arthur W. Gilmore
Grumman Aerospace Corp.

Irwin G. Greenfield
College of Engineering,
University of Delaware

Stanley Greenwald
ASME

William R. Grogan
Worcester Polytechnic Inst.

A.F. Hartford
E.I. duPont de Nemours & Co.

Norman Harvey
Manpower Administration, USDL

Daniel Hecker
Bureau of Labor Statistics

Edwin C. Jahn
SUNY College of Env. Sci & Forestry

A. Pemberton Johnson
New Jersey Institute of Tech.

David C. Johnson
Cornell University

Edward T. Kirkpatrick
Wentworth Institute

Israel Katz
Northwestern University

M.J. Kolhoff
General Electric Co.

Mr. & Mrs. Ronald E. Kutscher
Bureau of Labor Statistics

Fred Landis
College of Engr. & Appl. Sci.
University of Wisconsin at Milwaukee

Mr. & Mrs. Wm. K. LeBold
Purdue University

Bryce I. MacDonald
Kennecott Copper Corp.

Mr. & Mrs. Ray W. Mayhew
Battelle Memorial Inst.

Naomi J. McAfee
Westinghouse Electric Corp.

Paul J. McGrath
General Motors Corp.

J. Bruce Martin
Procter & Gamble

Donald B. Miller
IBM Corp.

Jean P. Moore
National Research Council

David E. Nicholson
The Boeing Co.

James R. O'Gwin
U.S. Energy R&D Adm.

Russell R. O'Neill
University of California at Los Angeles

Carolyn Phillips
Shell Oil Co.

Sydney Phin
Ingersoll-Rand Co.

K.G. Picha
School of Engineering
University of Massachusetts

K. Nagaraja Rao
MIT

Rebecca Rawls
Chemical & Engineering News

David R. Reyes-Guerra
Engineers' Council for Professional Development

Paul H. Robbins
National Society of Professional Engrs.

Harold E. Roush
RCA

Norman Seltzer
National Science Foundation

Mr. & Mrs. Dale O. Smock
Grove City College

Warren C. Stoker
RPI of Conn.

J.D. Strong
American Society for
Engineering Education

Mr. & Mrs. Alexander R. Susman
ASHRAE

Robert Thibodeau
U.S. Dept. of Transportation

Melvin Thompson
National Research Council

Myron Tribus
MIT

M.E. Van Valkenburg
University of Illinois

Betty M. Vetter
Scientific Manpower Commission

Cornelius Wandmacher
U. of Cincinnati

Robert K. Weatherall
MIT

George D. White
U.S. Civil Service Comm.

George P. Wood
Martin Marietta Corp.

Vincent P. Wright
Stone & Webster Engineering Corp.

Mr. & Mrs. Roger M. Zimmerman
New Mexico State Univ.